DN BADEN

'TO PULL OR NOT TO PULL'

BIOMECHANICAL REDUCTION TECHNIQUES IN ANTERIOR SHOULDER DISLOCATIONS

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Biomechanical Reduction Techniques in Anterior Shoulder Dislocations

David Nico Baden

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Biomechanical Reduction Techniques in Anterior Shoulder Dislocations

‘To Pull or Not To Pull’
Biomechanische reductietechnieken bij anterieure schouderluxaties
(met een samenvatting in het Nederlands)

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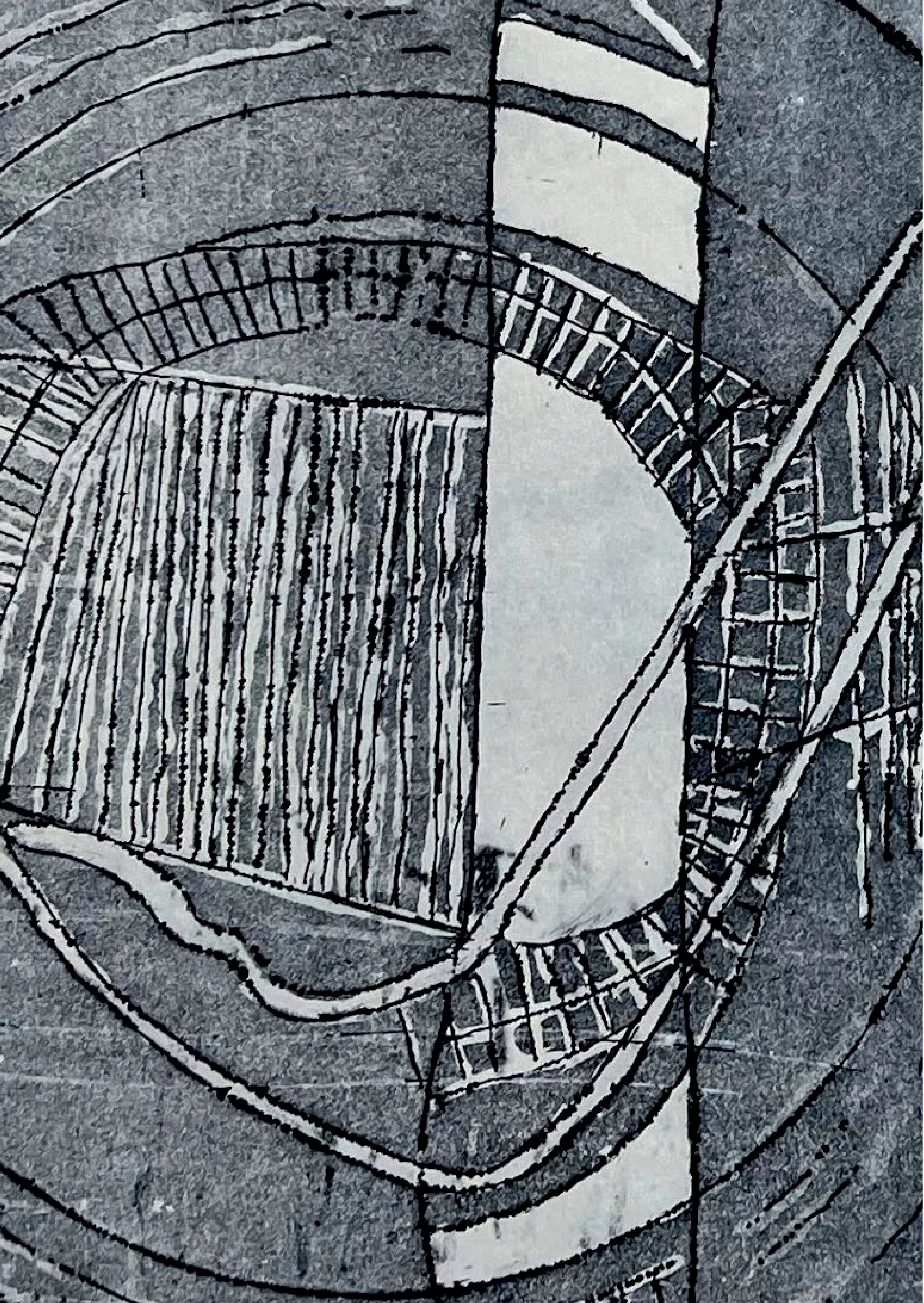
De kunst van de geneeskunde is
om de patiënt af te leiden
terwijl de natuur haar geneest.

*L'art de la médecine
consiste à distraire le malade pendant
que la nature le guérit - Voltaire*

TABLE OF CONTENTS



CHAPTER ONE

General introduction, aims and outline

MY STORY

Being on call for one of the first times as an emergency medicine resident, a patient arrived at the emergency department in severe pain. He grunted "it's my shoulder again" and was quickly transferred to an empty stretcher. My attending physician clearly stated instructions. We acted immediately.
A short-acting opioid was administered. A sheet was wrapped around the patient's chest. I held the sheet to provide countertraction while the attending physician pulled on the patient's arm with the dislocated shoulder. Although the patient begged us to stop because of intolerable pain, the attending physician kept going on, indicating it would only take a short time for the reduction to occur. After a few long minutes, a subtle "pop" was heard and a palpable clunk was felt, indicating a successful reduction. The patient experienced instant relief. I was thrilled with our intervention's obviously successful outcome. Despite the successful reduction, a lively discussion was initiated within our team.

We debated all kind of questions: What is the ideal setting and treatment for a patient with a dislocated shoulder? Was procedural sedation or even general anesthesia in the operating theatre more appropriate with this much pain for the patient? The latter, however, would take much longer and require a larger burden on hospital staff and equipment. One remark caught my attention and stuck with me: "There are techniques that are less painful. Wouldn't that be the optimal solution?"

Our discussion didn't end with consensus, not on any of the issues. For me though it sparked an investigation and an ongoing scientific search.

My focus of research became: How does a physician best help a patient with a dislocated shoulder quickly and efficiently without causing much additional pain while risking minimal additional damage to the shoulder and while using emergency department resources wisely.

INTRODUCTION

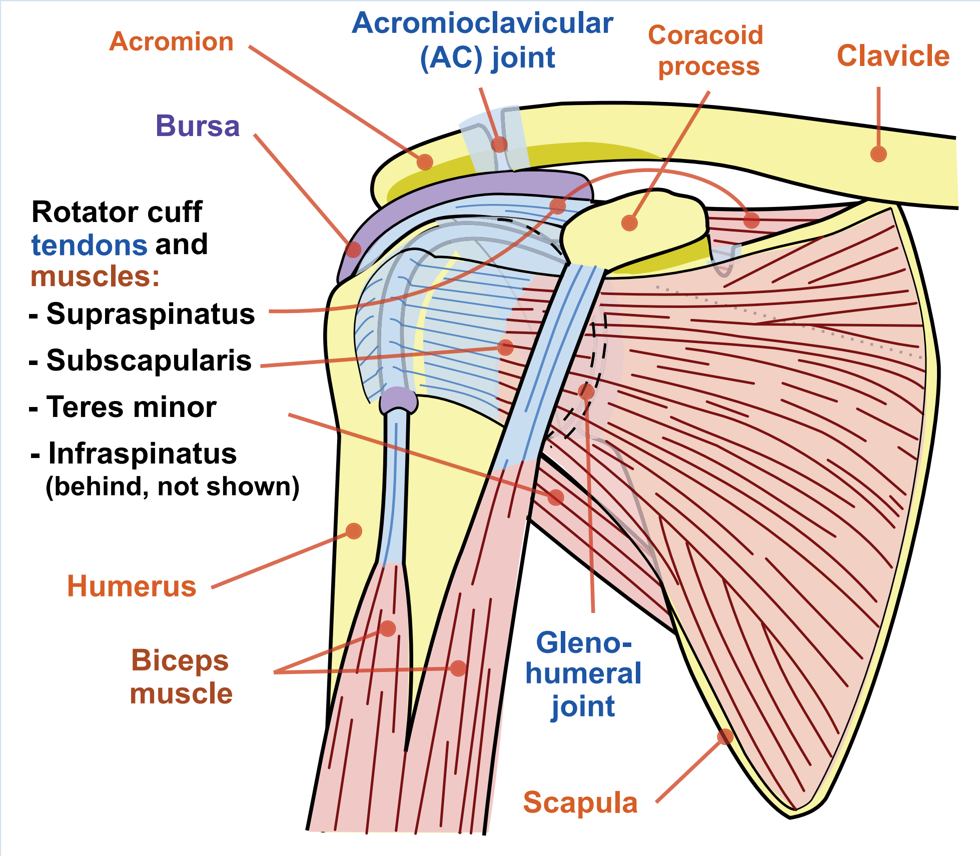
Shoulder anatomy – a thin line between a blessing and a curse

The shoulder is the body's most mobile joint, allowing for movement in six degrees of freedom – extension, flexion, adduction, abduction, and internal and external rotation. The osseous anatomy of a relatively large humeral head articulating with a smaller bony socket or glenoid permits this.

The shoulder's enormous range of motion is also its weakness, making it prone to dislocations. The glenoid labrum adds to the glenoid concavity, providing additional static restraint and stability. Shoulder stability is also enhanced by the glenohumeral ligaments and the joint capsule.

The primary muscles contributing to the shoulder's dynamic stability are the: supraspinatus, subscapularis, infraspinatus and teres minor - the rotator cuff muscles. In addition, the deltoid muscle plays an important role in arm elevation (see figure 1). Important adjacent neurovascular structures include the axillary nerve and artery.

Figure 1: Shoulder anatomy showing bones and muscles relevant to shoulder dislocations



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Anterior glenohumeral "shoulder" dislocation

With an anterior shoulder dislocation, several structures are acutely over-tensioned. The supraspinatus and infraspinatus tendons and muscles are most severely affected. This is thought to account for pain perceived above the level of the clavicle.

Additionally, possibly due to the humeral head's anterior position, tension on the bicep's long head increases. The resultant pain causes biceps muscle spasm. This, in turn, likely contributes to pain in the upper arm, but also difficulty in reducing the shoulder.

Patient presentation

This combination of factors likely explains why patients often present with their affected arm in slight abduction and external rotation. Patients frequently support their affected arm just distal to the elbow. This provides the most support for their stressed shoulder girdle musculature and helps minimize discomfort.

Shoulder dislocation, a common emergency department diagnosis

The incidence of shoulder dislocations is approximately 23 cases per 100,000 person-years, making it the most common dislocation worldwide requiring medical attention and presenting in the emergency room. Peak incidence occurs in men aged 25-30 years and women aged 50-70 years, with a male-to-female ratio of 3:1

The most common precipitants are falls and motor vehicle crashes. Rarely, but significantly, seizures and electrocution can cause shoulder dislocations. Three main types of dislocations exist, named for the humeral head's position relative to the glenoid, anterior (93-97%), posterior (1-4%) and erecta (0.5-1%).[1–4]

Potential neurovascular compromise

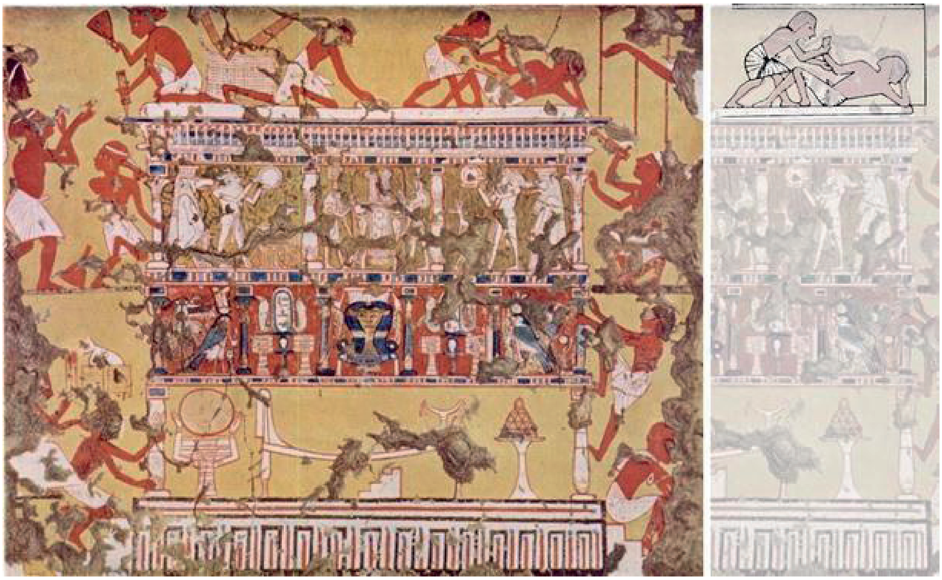
In nearly half of anterior shoulder dislocations, the axillary nerve, and more specifically its cutaneous branch to the deltoid, is trapped or abnormally stretched, resulting in a neuropraxia.[5] Patient's often indicate that they're numb in the so-called shoulder patch region of the deltoid. In more severe cases, nerve entrapment or damage can result in motor dysfunction. Damage to the axillary nerve can also result during reductions or reduction attempts. Axillary artery compression is rare but may result in vascular compromise to the patient's arm. This is reversible once arterial compression is resolved, generally by an expeditious reduction.

Pain and possible damage to neurovascular structures mandate timely shoulder reduction. Prolonged acute dislocations are generally thought of as leading to more challenging reductions, perhaps due to increased muscle spasm. This however is not well studied. Chronic dislocations produce irreversible osseous joint damage. Over extended time periods, fibrosis occurs, making reductions both impossible to perform and dangerous to perform due to the possibility of tearing blood vessels.

Shoulder dislocations, a historical perspective

Shoulder dislocations and reduction techniques are depicted in an Egyptian burial vault dating from approximately 1200 BC(figure 2). The reduction techniques shown were later more fully described by Doctor Kocher around 1870.[6]

Figure 2: Wall painting demonstrating a shoulder reduction technique in a Egyptian tomb



Tomb of Ipuy, wall painting (~1200 B.C.) Reproduced from: Davies, N. de Garis. Two Ramesside Tombs at Thebes. Robb de Peyster Tytus Memorial Series, Volume V. 1927. New York, The Metropolitan Museum of Art. (Plate XXXVIII)

Historically, Hippocrates seems most associated with shoulder dislocations. He is credited with describing seven reduction techniques.

In the centuries following Hippocrates' lifetime a multitude of techniques and devices to aid reduction have been described and used (figure 3). Today over 50 reduction techniques and their variants are known. Modern techniques are often remarkably similar to ancient ones.

Modern medical practice

There is no question that a patient with a dislocated shoulder requires rapid medical attention. Ideally, shoulder reduction is performed quickly, while causing limited, and tolerable, additional patient discomfort. Reductions should not place the patient at risk for complications.

In The Netherlands, most patients present to the emergency department (ED) for required help. Ideally, this is where shoulder reduction is performed quickly with minimal pain. The ED team benefits the hospital and the healthcare system by performing reductions without using outside resources. This allows quick discharges, reducing the impact of increasing patient numbers on the department and the hospital. Workload is minimized as well.

Figure 3: 16th century line drawing showing a shoulder reduction technique.

Les œuvres de M. Ambroise Paré … Avec les figures et portraicts tant de l'anatomie que des instruments de chirurgie, et de plusieurs monstres. Le tout divisé en vingt six livres., Paré, Ambroise, 1510?-1590.

Patients with a dislocation present in pain, therefore pain relief is often the first treatment step. However, the effectiveness of various pain management techniques is unclear and poorly studied as it relates to shoulder dislocations. A second issue is that reduction technique influences the amount of pain experienced. This phenomenon is also poorly studied. Also, the best pain relief approach during reduction and the influence of the operator's experience on patient's pain are largely unknown.

Pain relief

General comments

Ideally, analgesics used in this setting should act quickly and be short acting.
Scientific research in this area has focused on comparing pharmacological analgesic methods. However, reliable comparisons are complex and lacking in the shoulder reduction literature. Adequate comparisons require that pain medications be administered uniformly to all studied patients. More importantly, uniform reduction techniques must be used across different analgesics to allow for direct comparison. Unfortunately, few if any studies meet these criteria.

Medication administration methods and effectiveness

Since the goal is near-immediate pain relief, several assumptions are made about pain treatment strategies. Oral medication is unacceptable since a minimum of 30 minutes is required before acetaminophen or non-steroidal anti-inflammatories exert their effects. These medications are inadequate to treat moderate to severe pain. Fast-acting opioids seem more suitable and can be given intravenously or nasally. However, the analgesic effect of, for example, fentanyl, appears to be limited since it fails to adequately treat shoulder dislocation pain. Whether this is due to pain intensity or pain type or other factors is unknown.

Nerve blocks efficiently provide pain relief. However, nerve blocks require time to work—15 to 45 minutes—and add substantially to ED length-of-stay. Too, nerve blocks take extra time to perform.

Intra-articular lidocaine (IAL) is a promising alternative. Aside from the time-to-effect of 15 to 20 minutes, a 2012 Cochrane Review and a 2020 Best Evidence Topic Report concluded IAL is a reasonable pain relief option.[7,8]. Unfortunately, questions about the included studies remain, almost none describing the reduction technique used or whether the reductions were uniformly performed. Additionally, benzodiazepines and other sedation methods were used in anxiolytic doses and are not standardly dosed in this manner for mild or deep Sedation and Analgesia (PSA).[9]

PSA is another option that rapidly provides pain relief, sedation, muscle relaxation, a state in which the patient can tolerate an otherwise-painful procedure comfortably, and has amnesia for the event. This all can be achieved while the patient independently maintains oxygenation, ventilation, and airway control. An additional benefit is that several PSA agents are short acting and short lasting. However, high-quality comparative studies between PSA and other pain treatment strategies or placebo are lacking. Also, procedural preparation and medication administration requires extra time and personnel if PSA is to be properly and safely performed. The post-PSA period of observation to ensure safe ED discharge adds additional time to ED length-of-stay. Finally, not all reduction techniques are able to be safely performed in the mild to deep sedated patient. Despite these drawbacks, PSA remains a good option for patients requiring a shoulder reduction. PSA for this indication is broadly, and safely used worldwide.

Patient perspective and present state-of-the-art

It is generally thought that pain relief, proper and successful reduction, and minimal risk are the patient's priorities. As described, there are pros and cons to every pain relief method. In summary, they either provide inadequate pain relief, take too long to work, work erratically or insufficiently, take time to perform or require significant resources of material and personnel. PSA is widely considered to be optimal but requires extra time and the undisturbed attention of additional medical staff.

Future directions

Given the conundrum outlined above, the best approach may be to use a reduction technique or group of reduction techniques that cause minimal to no pain and therefore do not require pain management methods. This would give the patient pre-procedure comfort, relaxation, and cooperation. It is also important during the procedure when pain might otherwise be caused.

Reduction techniques and difficulties comparing outcomes

As noted, over 50 different reduction techniques are described in the medical literature, more if all variants of these techniques are included. Direct scientific comparison of these techniques is both incomplete and problematic. Primary confounding factors include reduction technique description and analgesic methods used. Despite the same name, techniques are described variably, and actual movements performed during reductions are vaguely described or not noted at all. As a result, meaningful comparison of reduction techniques in the current literature is difficult.

Reduction techniques - general mechanism of action

Despite the wide range of reduction techniques described, they can be divided into three groups based on mechanism of action:

- Traction/Countertraction:

In these techniques a certain level of traction is applied and exceeds muscle tension forces, therefore reduction occurs.

Hippocrates first described a traction/countertraction technique. In his original method the operator pulls on the patient's arm while exerting countertraction by placing his heel in the patient's axilla. Countertraction can also be provided by wrapping a sheet around the patient's chest and pulling opposite the direction of the traction on the arm.

Many traction/countertraction variants exist, including: Stimson, Eskimo-technique, Chair technique, Snowbird, Sosmat, Spaso, SRT, forward elevation and auto-reduction methods.[10,11] All traction/countertraction techniques usually require significant analgesia. Some are fraught with risk, including neurovascular damage and fracture.

- Lever techniques:
By moving the arm, a lever is made involving the glenoid and the humeral head, leading to shoulder reduction. In about 1870, Kocher described the best-known of these techniques, which still bears his name. Other examples of lever techniques are external rotation reduction methods. Fracture causation or worsening is a risk with external rotation methods.

These techniques can be, and frequently are, painful. Commonly, analgesia, and/or a cooperative and relaxed or stoic patient, is required.

- Biomechanical techniques
Here the focus is on promoting muscle relaxation, reducing muscle tension and spasm, and enabling or allowing the shoulder to reduce. Optimal patient comfort is paramount. In most of these techniques the patient is asked to shrug and move the shoulder back as through rolling his shoulder backward. This is thought to create more shoulder joint space and promote muscle relaxation.

The techniques use additional strategies to reduce muscle tension. In the Cunningham technique the elbow is flexed and positioned close to the body. This reduces biceps muscle tension and brings the humeral head closer to the glenoid.

In the Milch technique and its variants, FARES, and others, reduction is achieved through external rotation of the shoulder while the arm is brought into abduction at about 130 degrees. This provides supraspinatus and infraspinatus muscle relaxation. The arm and shoulder positioning described allow the biceps and triceps to pull the humeral head into the glenoid.

With scapular manipulation, the scapula, not the arm is moved. Therefore, the glenoid moves in the direction of the dislocated humeral head and reduction occurs.

Because the biomechanical techniques minimize tension on stressed, stretched and painful structures and focus on muscle relaxation and general patient relaxation, analgesics are rarely required if the techniques are performed correctly.[12–16]

FUTURE RESEARCH

Daily ED practice would benefit from clarity on preferred reduction method given patient presentation with all aforementioned factors accounted for.

As noted, reduction techniques should be evaluated based on efficacy, success rate, reduction ease and speed, risk of causing pain and risk of causing or worsening complications.

Several questions are worth considering.

- Which techniques are currently used in The Netherlands?
- Which factors influence ED length-of-stay?
- Does analgesic technique influence ED length-of-stay?
- Are there techniques, or groups of techniques, with superior outcomes considering reduction success, length-of-stay, complication risk and need for PSA or significant medication administration?

Central thesis question

These thoughts led to the main question outlined in this thesis: What is the preferred technique for reduction of an anterior shoulder dislocation **without** the use of analgesic techniques?

OUTLINE

Chapter two is a general introduction to the subject. Chapter three contains survey data on current management of shoulder dislocations in The Netherlands. Chapter four presents information on factors influencing ED length-of-stay for patients with a dislocated shoulder in two Dutch hospitals. Chapter five is a literature review analyzing reduction techniques across reduction success, patient pain experience and complication rates. Chapter six presents details of the protocol for a Randomized Controlled Trial (RCT) of biomechanical techniques. Chapter seven presents the RCT's results. Chapter eight is a summary of this thesis. It also contains a viewpoint on the future of shoulder dislocation treatment and research.

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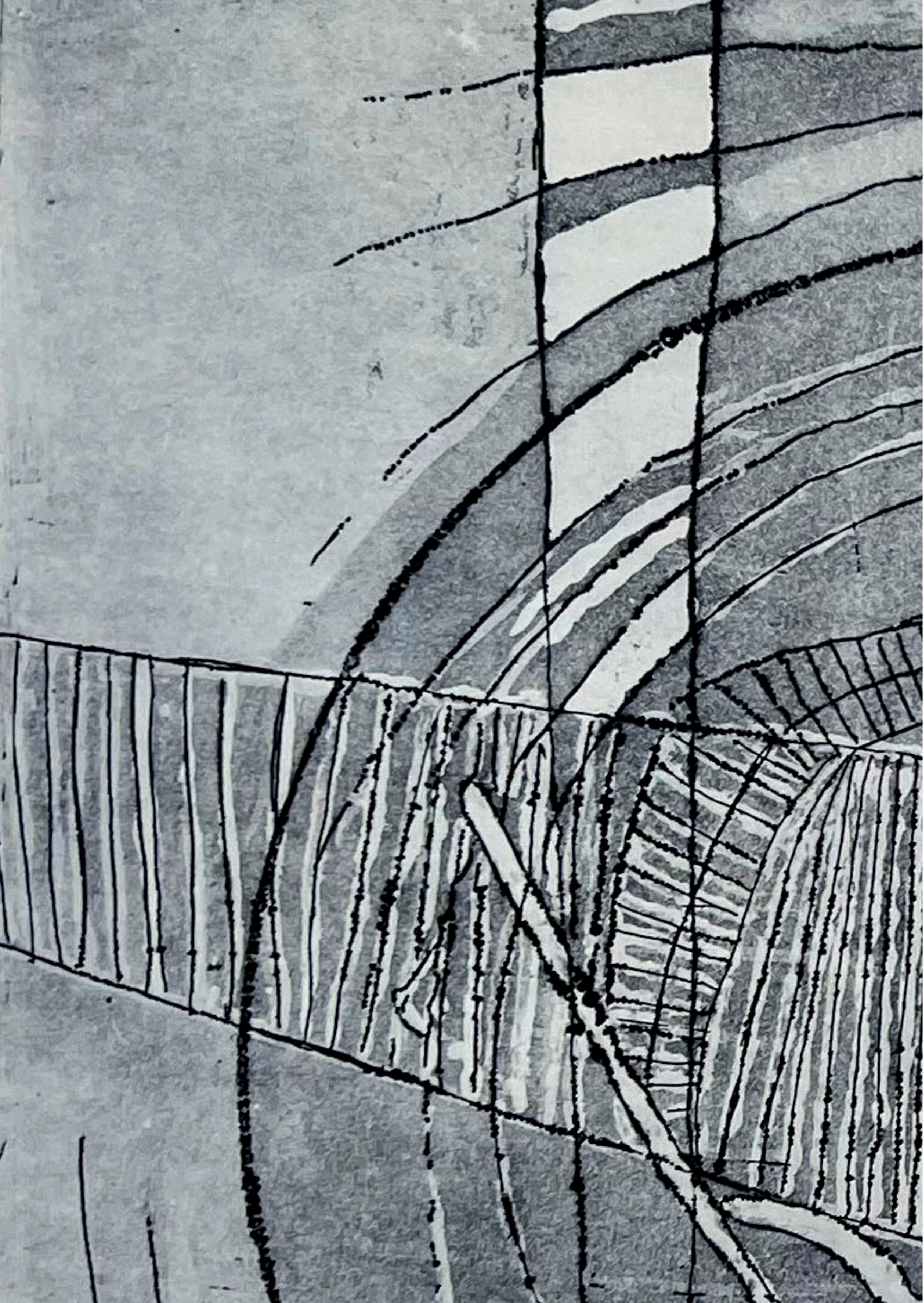

CHAPTER TWO

Assessment and management of shoulder dislocation

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INTRODUCTION

Shoulder dislocations are painful and have an impact on activities of daily living and participation in sports. Most shoulder dislocations (> 95%) occur in the anterior direction and are usually due to trauma. [1-3] It is observed that patients with first-time dislocations often receive insufficient information to decide about their management. [4] Optimal management can prevent recurrent dislocations (recurrence) and reduce social costs. [5-7] Shared decision making must take into consideration the patient's preferences for surgery or conservative management, their expectations, and the likelihood of recurrence. [7] In this clinical update we present an initial approach for primary care and emergency healthcare providers to assess and manage patients with a traumatic anterior shoulder dislocation, with a primary focus on first-time anterior shoulder dislocations.

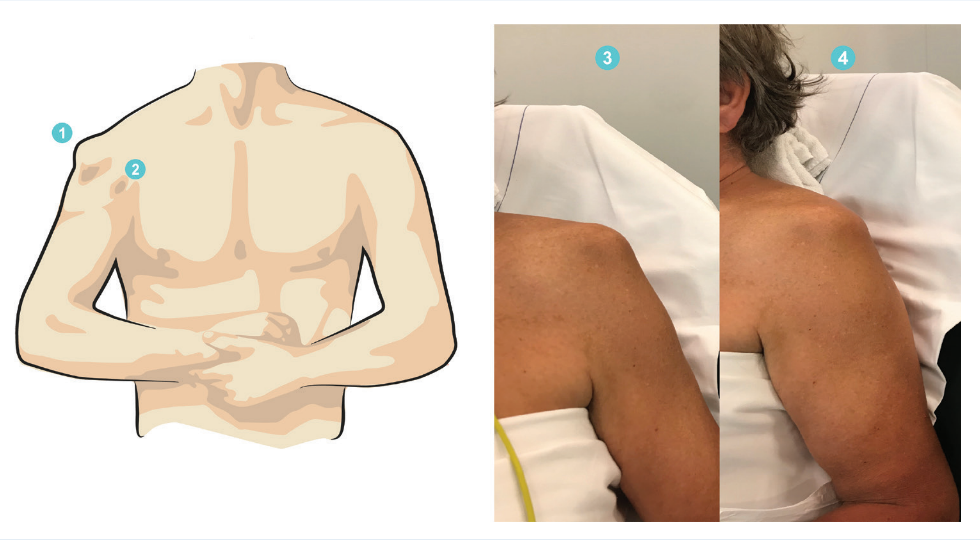
WHO EXPERIENCES A SHOULDER DISLOCATION?

Over 70% of shoulder dislocations occur in men. [1-3] In a large cohort study of 16,763 patients who experienced a first-time anterior dislocation in the UK, there was a peak incidence in young men aged 16 – 20 years (80.5 per 100,000 person-years) and older women aged 61 – 70 years (28.6 per 100,000 person-years). [3] These peak incidences are similar to cohorts in other western countries, such as Canada, the US and Norway. [2, 3] In young patients, shoulder dislocations most often occur during participation in contact and overhead sports, such as rugby, football and baseball. [1, 2] This also explains the peak incidence in young males, as they participate in these kinds of sports more frequently. [2, 3] Shoulder dislocations in older patients are most often due to a fall. [2] However, the cause for the peak incidence in older women remains unclear. [1, 3] A retrospective cohort study of 112 patients who experienced a posterior dislocation showed an incidence of 1.1 per 100,000 person-years and that approximately 30% is due to an atraumatic event, such as a seizure. [8] Inferior shoulder dislocations (luxatio erecta) are rare and have only been described in case reports or small case series.

HOW DO PATIENTS PRESENT?

Patients present with considerable pain and impaired motion following trauma involving the shoulder. The injured arm is slightly abducted and held by the other arm (figure 1), while bending forwards. A fall on the outstretched arm or a direct blow to the shoulder is the most common injury reported in a first-time anterior dislocation. However, any trauma to the shoulder can cause dislocation. The injury commonly occurs at home or during participation in overhead or contact sports. [2, 9, 10]

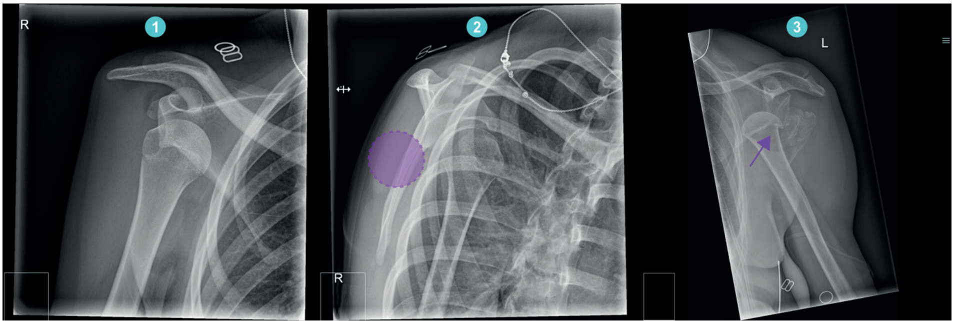
Figure 1. In an acute setting, a shoulder dislocation is characterized by an asymmetry of the shoulder contour on the injured side, as the humeral head has shifted frontwards and downwards (anteroinferior). A prominent acromion (1, 3 & 4) and a palpable humeral head (2) can be observed. The image of the shoulder contour (1 & 2) was created by T.H. Staal and the pictures 3 and 4 were taken by the authors at the emergency department of the Amsterdam UMC.



HOW TO DIAGNOSE AN ANTERIOR SHOULDER DISLOCATION AND ASSOCIATED INJURIES?

The mechanism of trauma and symptoms provide important diagnostic clues. On examination, a prominent acromion and asymmetry of the shoulder contour can be observed on the injured side, as the humeral head has shifted front and downwards (anteroinferior; figure 1).[11] The humeral head is not palpable anteriorly when a posterior dislocation is present (figure 1). The impalpable humeral head and mechanism of injury can be diagnostic clues for a posterior dislocation; however it is difficult to determine the direction of the dislocation without a radiograph and it is therefore used to confirm the diagnosis and record the dislocation for follow-up. [12, 13] In patients with suspected dislocation, request an anteroposterior and scapular 'Y' radiograph to confirm the diagnosis and reveal possible fractures (figure 2). [11, 13] Requesting 2 views is also recommended by the British Orthopaedic Association (BOA) guideline. [13] The Y radiograph uses a sagittal view where the scapula is shaped like a "Y" (figure 2). It can distinguish an anterior from a posterior or inferior dislocation. Fractures of the greater tuberosity can be detected with high sensitivity (94%) and specificity (95%) using radiographs (figure 2). [14] Risk factors for associated fractures include age > 40 years, first-time dislocation and high-energy trauma (e.g. fall from height). [11, 15]

Figure 2. This figure presents an AP radiograph (1 & 3) and a scapular 'Y' radiograph (2) that can confirm the diagnosis and reveal possible associated fractures (3). 1: The humeral head is positioned in front of the glenoid and this confirms a dislocation. 2: Shows a scapular 'Y' view that can help to distinguish an anterior from a posterior dislocation. The dotted circle demonstrates where the humeral head would have to be positioned to confirm a posterior dislocation. 3: Shows a confirmed shoulder dislocation with a greater tuberosity fracture. These radiographs were extracted from the database of the Diakonessenhuis by the authors.



Assess for damage to neurovascular structures before and after reduction as this can occur due to the dislocation or the reduction. [13] Damage to motor neurons can be quickly assessed by asking the patient to extend the fingers (radial nerve), spread the fingers (ulnar nerve) and oppose the thumb (median nerve). [16] Potential damage to the axillary nerve can be assessed by checking loss of sensibility on the lateral side of the upper arm (figure 3). Loss of sensibility in this region is often resolved after reduction. Radial pulse and capillary refill can be used to assess damage to vascular structures. However, damage to vascular structures is rare.

Figure 3. Sensibility of the lateral side of the upper arm can be assessed for potential damage to the axillary nerve. The marked area resembles the location of the 'shoulder patch'. The image of the shoulder patch was created by P.R. Zwanenburg.

WHAT ARE THE ASSOCIATED INJURIES?

Injuries associated with traumatic anterior shoulder dislocations include neurological deficits, greater tuberosity fractures and rotator cuff tears. [13, 17] A prospective trauma database study (3633 patients) showed that 14% of traumatic anterior dislocations were accompanied by a neurological deficit, 16% by a greater tuberosity fracture and 10% by a rotator cuff tear. [17] A peak incidence for neurological deficits was not observed, however risk of greater tuberosity fractures and rotator cuff lesions increased with age and was most common in patients aged > 40 years. [17] A prospective EMG study (77 patients) showed axonal loss in 48% of patients with an anterior shoulder dislocation and involvement of the axillary nerve in 42%. [18] Risk of nerve injuries increased with age and when a hematoma was present. [18] In addition, patients with associated fractures demonstrated nerve lesions in 71% of cases. Most patients showed a good recovery within 1 year, as normal muscle strength returned in 95%, however on average patients showed loss of movement in the injured compared to the healthy shoulder of 3 – 17 degrees. Damage to the axillary nerve is characterized by shoulder pain, loss of sensibility on the lateral side of the upper arm (figure 3) and weakness of the deltoid muscle (abduction). [19] An EMG after 3 weeks can be used to confirm nerve damage. Although high percentages of axonal loss are observed, patients show good recovery and persistent brachial plexus and peripheral nerve injuries are only present in < 1% according to a retrospective multicenter study (15,739 patients). [20] Rotator cuff tears can be difficult to diagnose clinically, however patients with a rotator cuff tear may benefit from operative treatment. Therefore, patients that experience persistent pain and are unable to regain function following physiotherapy should be referred to a shoulder specialist.

WHAT DOES INITIAL MANAGEMENT INVOLVE?

In accordance with the BOA guidelines, it is advised to refer patients with a first-time dislocation to the emergency department [11, 13, 16] for reduction as there could be accompanying fractures. Suspicion of fractures, vascular injuries, and neurological deficits that are not resolved after reduction would require referral to the emergency department as well. [11, 16] Only if a young (< 40 years) patient presents with a history of frequent dislocations subsequent to minimal trauma and without suspicion of associated injuries, immediate reduction in a primary care setting may be considered. [16]

Reduction

Famous examples of shoulder reduction techniques include the Hippocrates and Kocher method, which are based on traction and leverage. [21] There is no consensus regarding the most appropriate method, as most techniques demonstrate a high success rate. [21] However, a systematic review (1377 patients, 9 randomized controlled trials and 4 comparative studies performed at emergency departments) on closed reduction techniques for shoulder dislocations found that the biomechanical scapular manipulation and "Fast, Reliable, and Safe" (FARES) techniques were most successful in reducing the shoulder, showing success rates of 97% and 92% respectively. In addition, these techniques were less painful (1.47 and 1.59 on a visual analogue scale (VAS) of 1 to 10) compared to traction and/or leverage techniques (VAS > 4). [21] The biomechanical techniques, such as the scapular manipulation, FARES and Cunningham technique, focus on muscle relaxation and do not rely on traction and/or leverage (table 1). [22-25] The rotator cuff muscles are strained following a dislocation and relaxing the muscles is therefore a key element in allowing the humeral head to return to its original position. Due to small sample sizes and possible bias in studies, high-quality evidence assessing the most successful and least painful technique is still lacking. [16, 21, 22, 26] In addition, there is no evidence for shoulder reduction in primary care. None of the reduction methods are always successful and frequently more than one technique might be performed for a successful reduction. Although rare, post-reduction neurovascular complications and iatrogenic fractures have been reported for the Hippocratic and Kocher method. [27, 28] A retrospective cohort study of 92 patients > 40 years with a first-time dislocation demonstrated that 5% were identified with a post-reduction humeral neck fracture. [29] All of these patients presented with a greater tuberosity fracture pre-reduction. Unfortunately, it is unclear which reduction method was used in this retrospective study. As no complications have been reported following biomechanical techniques and since they are considered least painful, we advise professionals to rely on biomechanical techniques in a specialist and primary care setting (table 1).

In accordance with the BOA guidelines, it is advised to request a post-reduction radiograph to determine if the reduction was successful and if it caused any fractures. [11, 13]

Immobilize the shoulder

Immobilize the shoulder following closed reduction in either internal rotation (conventional sling) or in external rotation for 1 week (figure 4). This would reduce pain, prevent recurrence, and allow healing of the soft tissues or fractures. A Cochrane review of randomized controlled trials with ≥ 12 months follow-up showed a pooled recurrence rate of 30% following immobilization in internal rotation compared to 22% following immobilization in external rotation and determined this was very low quality of evidence and not statistically significant. [30] A systematic review of 2 well performed randomized controlled trials (190 patients) with ≥ 12 months follow-up showed a pooled recurrence rate of 41% following immobilization for ≤ 1 week compared to 37% for immobilization for ≥ 3 weeks in patients < 30 years and this was not statistically significant. [31] One of the randomized controlled trials included in the systematic review followed their patients for 25 years, however a difference in recurrence rates was still not observed at long-term follow-up. [31, 32]

Table 1. An overview that demonstrates how closed reduction techniques that focus on muscle relaxation, so called biomechanical techniques, are performed. With these techniques, it is important to make a patient feel comfortable to relieve shoulder muscle tension. The pictures were taken at the emergency department of the Diakonessenhuis by the authors.

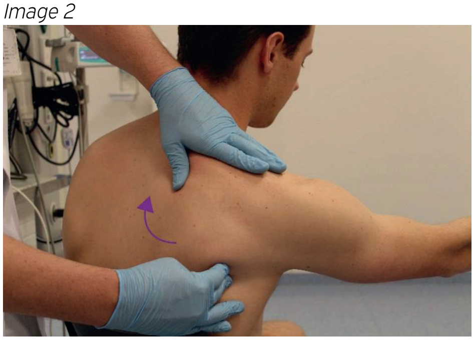
Biomechanical technique: Scapular manipulation

How to perform [24]

Facing the patient, grasp the wrist on the injured side and slowly extend the arm with the palm of the hand facing upwards (external rotation; image 1). A small degree of forward traction is applied with counterbalancing provided by placing the free hand on the midclavicular region (image 1). Be sure to apply little force, as applying too much force can be painful. Once traction is applied, a colleague manipulates the scapula by applying constant traction to the externally rotated humerus to reduce pressure of the humeral head on the glenoid rim (sitting supralateral to the dislocated head). This allows the abducted inferior tip of the scapula to be rotated, bringing the scapular neck and glenoid fossa into alignment (image 2) The shoulder is reduced when the scapula moves and you feel the humeral head going back into position.

Image 1

Image 2



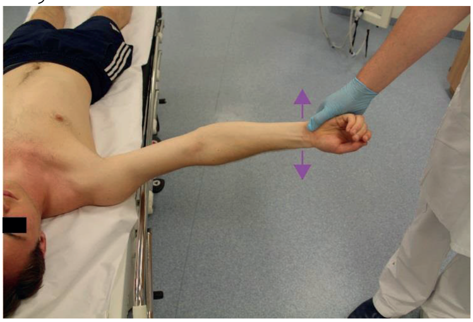
Biomechanical technique: Scapular manipulation

How to perform [23]

Ask a patient to lay down on a flat surface (e.g. hospital bed). Fully extend the elbow and gently place the arm in maximal external rotation, without causing discomfort (image 1). Apply gentle longitudinal traction and slowly move the arm into abduction, without using countertraction. Continuously perform brief (two to three full "cycles" per second), and "short-range" (approximately 5 cm above and beneath the horizontal level) vertical oscillating movements while abducting the shoulder (image 2). Past 90° of abduction, gently externally rotate the arm even further while keeping up the vertical oscillating movements and abducting the shoulder. Reduction is usually successful around 120° of abduction, however keep up the movements until approximately 170-180 degrees. The arm can be placed on the chest when reduction is successful.

Image 1

Image 2



Biomechanical technique: Cunningham

How to perform [25]

The patient sits upright in a hard backed chair with the injured arm adducted to the body and the elbow fully flexed (image 1). Kneel or sit down next to the patient and place their hand on your shoulder, while putting your hand on their forearm (image 1). It is important to keep the elbow flexed to relax the bicep muscle. Do not apply pressure, as this can be painful for the patient. Ask the patient to shrug the shoulders superiorly and posteriorly to reduce obstruction of the glenoid rim. Massage the muscles surrounding the shoulder. Start with the trapezius and deltoid muscles and afterwards move to the biceps muscle (image 2). The biceps is massaged at mid-humeral level to remove the dynamic obstruction that this muscle causes within the shoulder. The massage is not meant to relax the muscles, but to make the patient conscious of their muscle tension. Reduction is often successful after a couples of minutes and is expected when the shoulder contour has been restored.

Image 1

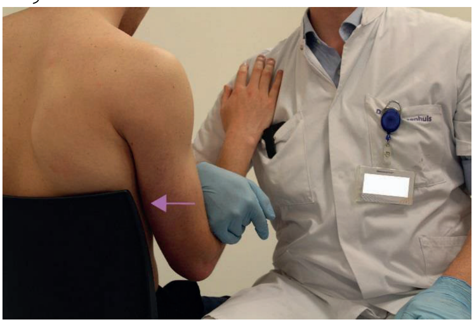


Image 2

Figure 4. The position of the arm in immobilization in internal rotation (1) and immobilization in external rotation (2). These pictures were taken at the emergency department of the Diakonessenhuis by the authors.

WHAT FACTORS INCREASE THE RISK OF RECURRENCE?

A systematic review (10 cohort studies, 1,324 patients) showed that up to 40% of patients experience recurrence or subluxations ≥ 12 months following a first-time dislocation. [10] In a prospective cohort study (252 patients aged < 35 years) over 85% of these dislocations were experienced within 2 years. [33] The systematic review also demonstrated high-quality evidence that young patients (≤ 40 years) are 13 times more likely, males are 3 times more likely and patients with hyperlaxity are 3 times more likely to experience recurrence (defined as a complete dislocation or subluxation; supplementary 1). [10] In addition, it showed that patients with a greater tuberosity fracture were 7 times less likely to experience recurrence. [10]

WHICH PATIENTS BENEFIT FROM OPERATIVE TREATMENT POST-REDUCTION?

Weighing the benefits and risks of conservative and operative treatment following a first-time dislocation can be challenging for both patients and healthcare professionals. A prospective cohort study with 25 years follow-up (255 patients) showed a recurrence rate of 60% following non-operative treatment, which involves physical therapy with scapula and rotator cuff training. [32, 34] Operative treatment involves arthroscopic repair of the capsule and labrum complex with/without tenomyodesis of the infraspinatus tendon (remplissage) or a more invasive procedure in which a bone graft is added to the glenoid (bone augmentation). [35, 36] A systematic review of cohort and comparative studies showed a pooled recurrence rate of 16% (2693 patients) following the labral repair, 9% (219 patients) following the labral repair with remplissage and 6% (905 patients) following the bone augmentation procedure. [36] The bone augmentation procedure demonstrates the lowest recurrence rate, however this systematic review also showed a complication rate of 5% compared to < 2% for the labral repair with/without remplissage. [36] Hardware failure, non-union/fracture of the graft, hematoma and temporary nerve injury are the most common complications following bone augmentation procedures and shoulder stiffness is the most common complication following labral repairs. [36] It has been shown that operative treatment can reduce the recurrence rates significantly, however which patients are most likely to benefit from operative treatment? A well conducted randomized controlled trial (65 patients after a first-time dislocation) with a follow-up of > 12 years comparing the labral repair with sham surgery showed that the labral repair demonstrated lower recurrence rates in young (< 35 years) patients. [37] Recurrence was observed in 12% following the labral repair and in 47% following sham surgery and this was statistically significant. Patients aged > 40 years are less likely to experience recurrence and may benefit from non-operative treatment. [38, 39] Risk of experiencing recurrence in these patients is probably linked to the presence of associated injuries, such as the aforementioned rotator cuff tear. [38, 39] Operative repair of the rotator cuff tear may be beneficial for some patients (e.g. patients with a healthy rotator cuff), however a retrospective case series (67 patients aged > 60 years) demonstrated better recovery of shoulder function following non-operative treatment compared to a rotator cuff repair. [38, 39] Therefore, patients with a suspected traumatic rotator cuff tear should be referred to a shoulder specialist for further assessment. High-quality evidence that determines risk factors or evaluates benefits of operative treatment in older patients is lacking. Participation in (competitive) sports and activity level are important factors in decision making as well. Participation in contact sports, such as rugby, football, basketball and hockey increase risk of recurrence and these patients may benefit from operative treatment. [40] A systematic review (17 studies, 642 patients) evaluating return to sport in athletes aged ≤ 18 years showed that 41% return to sport (return to pre-injury level or higher) following conservative treatment and 95% return to sport following operative treatment. [41] Prognostic factors that facilitate predicting a successful return to sport following operative treatment are still lacking. A systematic review including long-term cohort studies (1,832 patients) showed an overall increase in degree of post-dislocation osteoarthritis compared to the contralateral shoulder. [42] If the rate of post-dislocation osteoarthritis can be reduced with surgery, this may be important in decision making. However, conservative and operative treatment showed similar proportions of radiographic osteoarthritis. [42] The bone augmentation may demonstrate a lower degree of osteoarthritis, however this is based on low-quality evidence with a wide variety in follow-up.

PATIENT PERSPECTIVE

I experienced my first shoulder dislocation in 2015. This was a painful and scary experience. The only thing I could think of was: "This pain must stop!" I was brought to the emergency department and received medications to reduce the pain and help me relax. The reduction was successful after the first attempt and decreased the pain considerably. After a week of immobilization, I met with an orthopedic surgeon and we decided on physiotherapy. I started to work out and participate in kickboxing gradually. Unfortunately, I experienced a dislocation again 3 years later. This was much worse and several attempts were needed to reduce my shoulder. Physiotherapy did not help this time. My shoulder felt unstable. We decided to go for surgery to prevent recurrence and so I could return to a high activity level. I am satisfied with the surgery. I have since experienced dislocation of my other shoulder as well. My experience showed me that it is important for doctors to discuss the treatment options and reach a shared decision with the patient based on activity level and risk of recurrence.

SOURCES AND SELECTION CRITERIA

We searched Pubmed/Medline, EMBASE, Web of Science and Cochrane databases from 1990 to April 2020 using the terms "first/initial/primary/acute," "shoulder dislocation," "surgery/ operative," "conservative/non-operative" and "sham surgery." We included systematic reviews, randomised trials or comparative studies reporting outcomes following operative treatment for a first-time dislocation versus conservative treatment or treatment for recurrent dislocations (recurrence) We also searched Pubmed/Medline and Cochrane databases using the terms "first/initial/primary/acute," "shoulder dislocation," "risk," "diagnosis," "return to sport" and "closed reduction" to find systematic reviews and relevant studies on first-time dislocations. We referred to the National Institute for Health and Care Excellence (NICE), British Orthopaedic Association (BOA), Dutch Federation of Medical Specialists and National Center for Complementary and Integrative Health (NCCIH) databases for guidelines on traumatic first-time anterior shoulder dislocations.

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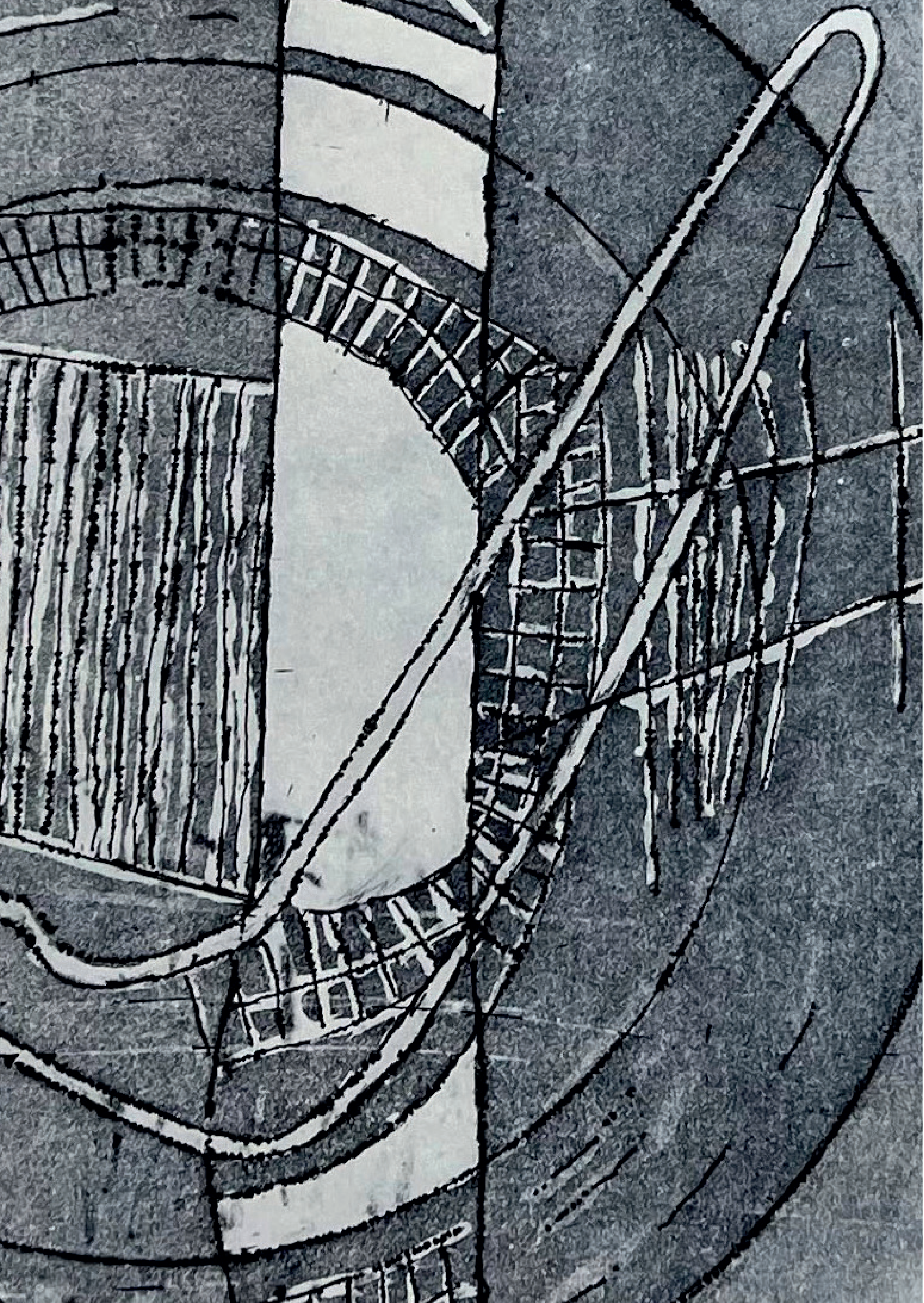
SUPPLEMENTAL MATERIAL

Supplementary 1. An overview of the risk factors, how they were defined and how many studies (n) evaluated the factors that are associated with recurrent dislocations (recurrence) following a first-time anterior shoulder dislocation according to the systematic review by Olds et al (9). Percentages were extracted or calculated if it was considered high-quality evidence.

Risk factor	Definition	Studies (n)	Association	Quality of the evidence
Age	< 40 years	10	Age is a **risk factor** for recurrence. Recurrence was observed in 44% of patients < 40 years and 11% > 40 years. The authors calculated that patients < 40 years were **13 times more likely** to experience recurrence.	High
Gender	Male gender	7	Male gender is a **risk factor** for recurrence. Recurrence was observed for 47% in males and 27% in females. The authors calculated that male patients were **3 times more likely** to experience recurrence.	High
Hyperlaxity	Beighton score (joint laxity assessment) of ≥ 4.	2	Hyperlaxity is a **risk factor** for recurrence. Recurrence was observed in 60% of patients with and 34% without hyperlaxity. The authors calculated that patients with hyperlaxity were **3 times more likely** to experience recurrence.	High
Greater tuberosity fracture	Avulsion fracture, where the attachment of the supra/infraspinatus tendon is pulled off the humeral head	7	A greater tuberosity fracture is a **protective factor** for recurrence. Recurrence was observed in 3% of patients with and 30% without a greater tuberosity fracture. The authors calculated that patients with a greater tuberosity fracture were **7 times less likely** to experience recurrence.	High
Bony Bankart lesion	Fracture of the anterior glenoid rim	4	A bony Bankart lesion **may be a protective factor**, however this was not statistically significant. It is difficult to identify this lesion on a radiograph.	Low
Hill-Sachs lesion	Impression fracture on the posterior humeral head	3	A Hill-Sachs lesions **may be a risk factor**, however it is present following almost any dislocation. It is difficult to identify this lesion on a radiograph	Low
Occupation	People who work with arms above their head and manual labourers	2	Occupation, as defined in these studies, **may be a risk factor**.	Low
Physical therapy	Participating in/Duration of physical therapy	2	Participating in physical therapy **may be a protective factor**. However, variability between the two studies was observed.	Low
Nerve palsy	A lack of function of the nerve (e.g. loss of sensibility)	2	Nerve palsy **may be a protective factor**. However, this was not significant and the two studies showed variability.	Low



CHAPTER THREE

A Survey of Emergency Providers Regarding the Current Management of Anterior Shoulder Dislocations

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ABSTRACT

Background

Anterior shoulder dislocations are frequent painful injuries commonly treated in the emergency department. The last decade new potentially less traumatic and painful reduction techniques for anterior shoulder dislocations have been introduced. Recent literature comparing best reduction techniques, medication use and approaches is limited. In order to better guide future research including the use of these newer techniques, information about the current use of different reduction techniques and medication is needed.

Methods

Our primary aim was to survey the techniques used by emergency practitioners to reduce anterior shoulder dislocations. Our secondary objective was to gather data on medication usage during reduction. To these ends, we surveyed members of the Netherlands Society of Emergency Physicians.

Results

Forty-four percent of respondents reported using a traction-based technique (Hippocrates or Stimson). Biomechanical techniques were used by forty percent of respondents. Twelve percent reported using the Kocher leverage-based technique. Five percent of the techniques used could not be classified.

A wide variety of procedural sedation and pain management interventions were reported, with morphine and propofol being used most. Approximately 9% of the reductions were attempted without any medications.

Conclusions

To our knowledge, this is the first study of its kind on anterior shoulder dislocation management by emergency practitioners. Our results indicate that Dutch emergency practitioners employ all three classes of reduction techniques: traction-counter traction most commonly, closely followed by biomechanical techniques. Medication use during repositioning varied widely. Per our survey, emergency practitioners are desirous of an evidence-based guideline for anterior shoulder dislocation management.

Keywords: Anterior shoulder dislocation, glenohumeral dislocation, biomechanical reduction techniques, emergency department

BACKGROUND

Anterior shoulder dislocations (ASDs) are commonly managed by emergency practitioners. [1] However, little unambiguous scientific evidence exists about optimal ASD reduction techniques and medication use to affect such reductions. More than 50 ASD reduction techniques are described, making it difficult to determine a "best" technique or approach for each ASD encountered. [2,3] In preparation for such a study, and to narrow the options for a randomized controlled trial, it would be helpful to know the techniques and medications most used presently. Two studies do exist comparing ASD reduction techniques most commonly used by orthopedic surgeons. [4,5] However, these data cannot necessarily be extrapolated to emergency department practice by emergency practitioners.

To shed some light on this knotty subject, we surveyed ASD repositioning techniques used by emergency physicians (EPs) and emergency medicine residents (EMRs). We also assessed "backup plans" in cases with first-attempt failure, and medication usage. Additionally, we sought to determine the interest level of emergency practitioners in an evidence-based medicine (EBM) ASD management guideline.

METHODS

In late 2015, Netherlands Society of Emergency Physicians (NSEP) members were emailed a Survey Monkey® web link with reminders emailed one and two months later. The questionnaire was sent to 587 individual members and contained nine questions in Dutch covering: techniques used, shoulder reduction experience, medications used and the perceived need for an evidence-based ASD management guideline (see Figure 1 for full questionnaire, translated into English). IP addresses are automatically logged in Survey Monkey®. Questions could not be left unanswered without a reason and the questionnaire could not be submitted if any question remained unanswered. All open-ended responses were reviewed by two of the authors (DB and MR) to check the spelling of the techniques or match a description with a technique. If there was no consensus or the technique was not known and could not be found in the literature, it was catalogued as "others." Results were analyzed with IBM SPSS Statistics for Windows, Version 21.0., released 2012. We used frequency tables for the techniques and medications used. We did cross tables for experience compared to medication, experience compared to education and interest in an EBM guideline compared to experience. We performed a Pearson Chi Square analysis to show statistical significance in these cases. Because this study surveyed physicians, no ethical approval was needed per Dutch law.

Figure 1: Questionnaire translated from Dutch

1. What is your function?
   Emergency physician
   Resident emergency medicine
   Other.....

2. Experience in repositioning anterior shoulder dislocation?
   <10
   10-50
   50-100
   >100

3. Is there a protocol in your hospital for the repositioning of anterior shoulder dislocation?
   Yes
   No

4. Preferred first technique used in the repositioning of anterior shoulder dislocation?
   Free text

5. Preferred second technique used in the repositioning of anterior shoulder dislocation?
   Free text

6. Medication commonly used in the repositioning of anterior shoulder dislocation?
   None
   Non-steroidal anti-inflammatory drugs (NSAID)
   Fentanyl intravenous
   Fentanyl intranasal
   Morphine intravenous
   Midazolam
   Propofol
   Esketamine
   Diazepam
   Lidocaine intra-articular
   Free text

7. Estimated first time success?
   <50%
   50-75%
   75-95%
   >95%

8. Did you ever encounter complications during the repositioning of an anterior shoulder dislocation?
   Yes
   No
   Free text for explanation

9. Would you like to have an evidence-based guideline for the repositioning of anterior shoulder dislocation?
   Yes
   No

RESULTS

Respondents numbered 158 - 112 EPs (26%) and 46 EMRs (29%). Nearly two thirds of the respondents claimed to have reduced more than 50 ASDs.

In first reduction attempts, traction-based techniques (Hippocrates 25.3%, Stimson 18.4%) predominated slightly at 43.7%. Biomechanical repositioning techniques were used first by 39.2% of the respondents (Cunningham 23.4%, Milch 11.4%, and scapular manipulation 4.4%). These techniques depend on muscular relaxation without the application of force and include the Cunningham, modified Milch, scapular manipulation and the FARES technique. [1-5] Kocher's leverage technique was used by 12.0%, and 5.1% of techniques could not be classified (see Table 1). Table 2 lists the second techniques used if a first reduction attempt failed. In this circumstance, emergency practitioners used traction-based techniques 39.9% of the time, biomechanical techniques 32.4% of the time and leverage techniques 19% of the time. A second technique was omitted in 4.4% of surveys and 4.4% of the techniques used were not specified. We did comparisons between EP and EMR practice patterns but these differences were not statistical significant.

Table 1: First technique used for reduction

	Frequency	Percentage
Hippocratic	40	25.3
Cunningham	37	23.4
Stimson	29	18.4
Kocher	19	12.0
Modified Milch	18	11.4
Scapula Tilt	7	4.4
Others	8	5.1
Total	158	100.0

Table 2: Second technique used for reduction

	Frequency	Percentage
Hippocratic	43	27.2
Kocher	30	19.0
Modified Milch	20	12.7
Stimson	20	12.7
Scapula tilt	17	10.8
Cunningham	14	8.9
No second technique	7	4.4
Others	7	4.4
Total	158	100.0

Twenty-three percent of respondents reported a greater than 95% first-attempt success rate. Approximately 80% of all practitioners indicated a greater than 75% first-attempt success rate.

Table 3 lists medications used to facilitate reduction. Multiple answers were allowed (eg. morphine AND propofol). Nearly 9% of respondents indicated no medication usage. Morphine was the most used analgesic and propofol the most commonly used sedative.

Forty-four percent of respondents indicated that their hospital had an ASD reduction protocol. Physician awareness of protocol existence did not significantly affect choice of reduction method.

Seventy-four percent of respondents indicated that an evidence-based ASD guideline would be helpful (see Table 4). This interest was most pronounced in the least-experienced physicians.

Table 3: Medication used (multiple responses possible)

		Responses	
		N	**Percentage**
Medication	Intra-articular lidocaine	100	26.3%
	Fentanyl intravenous	81	21.3%
	NSAID*	51	13.4%
	Propofol	44	11.6%
	None	34	8.9%
	Fentanyl nasal	29	7.6%
	Midazolam	18	4.7%
	EsKetamine	13	3.4%
	Morphine intravenous	9	2.4%
	Diazepam	1	0.3%
Total		380	100.0%

* non-steroidal anti-inflammatory drugs

Table 4: Interest for guideline compared to number of reductions performed

Number of reductions performed			EBM* guideline wanted		Total
			Yes	No	
	<10	Number of responses	7	0	7
		Percentage of group	100.0%	0.0%	100.0%
	10-50	Number of responses	36	11	47
		Percentage of group	76.6%	23.4%	100.0%
	50-100	Number of responses	46	9	55
		Percentage of group	83.6%	16.4%	100.0%
	>100	Number of responses	24	20	44
		Percentage of group	54.5%	45.5%	100.0%
Total		Number of responses	113	40	153
		Percentage of total	73.9%	26.1%	100.0%

* Evidence-based medicine

DISCUSSION

To our knowledge, this is the first study of its kind on ASD management by emergency practitioners. Two earlier studies of orthopedic surgeons found that they relied heavily on traction- or leverage-based techniques. [6,7] In contrast, Dutch emergency practitioners employ a wider range of techniques. Biomechanical techniques in particular are more likely to be used by EPs and EMRs.

Traction-based technique use does remain high amongst emergency practitioners, despite increased complication risk, particularly nerve damage. [8,9] Also leverage techniques are not without possible adverse effects, especially humeral spiral fractures in older patients or axillary vessel rupture.[10,11] Continued use of these techniques maybe be due to a variety of factors including: the lack of literature support for one particular technique, comparable success rates with a wide variety of techniques, familiarity with traction-based techniques, and most Dutch reduction protocols including only traction-countertraction and leverage-based techniques. Also these techniques cause pain and often mandate procedural sedation and analgesia as a consequence, causing prolonged ED lengths-of-stay. [12–14]

Our survey results indicated high interest in an evidence-based ASD reduction guideline. Also, the negative effects of traction-based technique and leverage techniques (particularly pain, and the resultant need for medication with its attendant prolonged ED stay, amongst others) may argue for such guideline. This point is of course countered by the lack of evidence favouring the use of any one technique or series of techniques.

Although "first attempt" was undefined in our survey, respondents reported a high first-attempt success rate. This is in keeping with other literature showing success rates in general for ASD reductions of 60 to 100% regardless of approach. [9,15]

Medication use by our respondents spanned the usual spectrum described in the present medical literature. [16–23] Surprisingly, nitrous oxide use was not reported. Also surprising was the high use of intra-articular lidocaine (27%). Our respondent's reliance on propofol probably stems from its status as the "drug of choice" in the NSEP's procedural sedation and analgesia guideline.

As a result of this study and the available literature we think that randomized high-quality prospective trials are needed to provide more evidence on optimal ASD repositioning techniques. Further studies on optimal medication use for ASD reductions are needed as well. Taken together, these new bodies of knowledge could form the basis for an evidence-based ASD management guideline since there is substantial interest in such guidance.

A randomized trial covering all ASD reduction techniques would be logistically impossible due to the wide range of techniques available. However, narrowing study focus to the commonly-used biomechanical techniques with their more favorable adverse-effect profile could be both fruitful and feasible. We are tantalized by our experience that suggests a high repositioning success rate, a better patient experience, less medication use, and a shorter ED length-of-stay with biomechanical technique reduction use.

LIMITATIONS

Our survey is hampered by its reliance on practitioner memory and self-report. Because no supporting documentation is demanded for survey answers, it is possible that answers to key survey questions are incorrect. Additionally, the direction and magnitude of this possible "incorrectness" is impossible for us to ascertain.

No cookies were used to identify unique users and the link was not password protected. However, because a limited group received the e-mail, no incentive was included and the survey was voluntary, it would be highly unlikely that the same person repeatedly completed a questionnaire or shared the questionnaire with others to complete. We did check to see if any IP address had unusually high returns but did not find that occurrence. Survey Monkey® cannot report survey view rates, but we reasonably expected that if physicians opened the link they also completed the questionnaire.

Because we did not perform a pre-survey pilot, it is possible that respondents interpreted the questions differently from our intention. This misinterpretation is also possible with the description or terms that the respondents provided for the techniques they use in repositioning. There is a risk that the participants used a different term or meant a different technique. We also omitted some follow-up questions to keep the questionnaire brief, to limit survey-completion time, and to attempt to increase the number of respondents. As a result, the information gathered may be insufficient to capture all the details of emergency practitioner approach to ASD.

ASD-management complications were rarely reported by survey respondents limiting our ability to draw conclusions about this. It is also possible that under-reporting, late complications or post-ED-discharge complications occurred that would not be captured by our survey.

Our relatively low survey response rate of 27% may limit our ability to draw statistically valid conclusions. However, we did receive responses from 66% of Dutch EDs, representing a continuum of teaching hospitals, academic and community hospitals and high- and low-volume institutions. We did collect data from a broad spectrum of Dutch emergency practitioners and only completed questionnaires are included. Also, recent research shows that a low survey response rate does not necessarily directly reduce results quality. [24]

This study involved only Dutch EPs and EMRs, thus making it difficult to generalize these findings. The nature of health care in the Netherlands is comparable to that of other western countries, but it may not reflect on the practice in other healthcare systems. [25]

CONCLUSIONS

Our survey demonstrated that Dutch EPs and EMRs most commonly use traction-countertraction techniques for ASD reduction. They also commonly use biomechanical techniques as well. Medication use to effect reduction and control pain, relief distress and achieve muscle relaxation varies widely. ASD management guidelines are strongly desired by emergency practitioners. These three findings should help shape the direction of future ASD management research.

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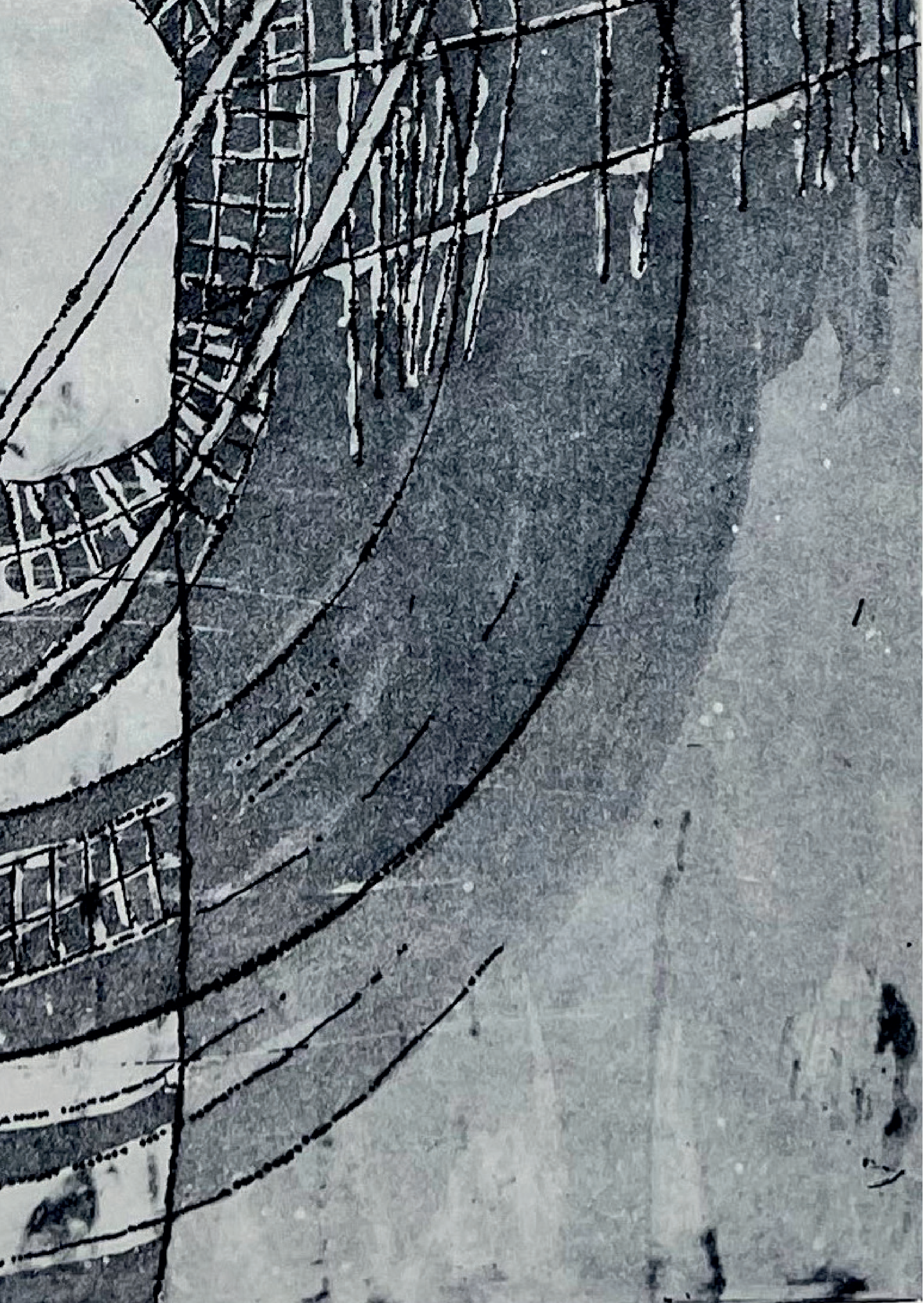

CHAPTER FOUR

Which factors influence the ED length-of-stay after anterior shoulder dislocations: a retrospective chart review in 716 cases

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ABSTRACT

Background

Anterior shoulder dislocations (ASD) are commonly seen in Emergency Departments (ED). ED overcrowding is increasingly burdening many healthcare systems. Little is known about factors influencing ED length-of-stay (LOS) for ASD. This study defines the factors influencing ED LOS for ASD patients.

Methods

Retrospective chart reviews were performed on all patients ≥12 years admitted with an anterior shoulder dislocation at two regional hospitals in the Netherlands between 2010 and 2016. The electronic patient records were reviewed for baseline patient characteristics, trauma mechanism, reduction methods, medication used, complications and the LOS at the ED. The main objective was determining factors influencing the LOS in patients with an anterior shoulder dislocation at the ED.

Results

During the study period, 716 ASD occurred in 574 patients, 374 (65.2%) in males. There were 389 (54.3%) primary ASD; the remainder (327, 45.7%) were recurrent. Median LOS was 92 minutes (IQR 66 minutes), with a significantly shorter LOS in those with recurrent dislocations ($p<0.001$), younger age group ($p<0.03$) and in patients who received no medications in the ED ($p<0.001$). Traction-countertraction and leverage techniques were associated with a significant more use of ED medication compared to other techniques. Although the use of more medication might suggest the LOS would be longer for these techniques, we did not find a significant difference between different reduction techniques and LOS.

Conclusion

To our knowledge this study is the largest of its kind, demonstrating ED LOS in ASD patients is influenced by age, the need for medication and dislocation history, primary versus recurrent. Notably, we found that biomechanical reduction techniques, which are not primarily traction-countertraction or leverage techniques, e.g. scapular manipulation and Cunningham, were associated with less ED medication use. Further research is needed to define how reduction methods influence ED medication use, patient satisfaction and ED throughput times.

BACKGROUND

The highly mobile glenohumeral joint is the most commonly dislocated large joint with an annual incidence of 8-27 per 100,000 population.[1–3] The incidence of shoulder dislocations in the Netherlands is estimated to 5,100 every year.[3] A vast majority of these dislocations are anterior, with the dislocated humeral head abnormally positioned anterior to the scapula. No consensus exists on the "best" anterior shoulder dislocation (ASD) reduction technique, nor does consensus exist for optimal medication use to effect ASD reduction.

Over 2,000 years ago Hippocrates of Kos described a reduction method that is still used today. Many more reduction techniques have been described and are currently practiced. Techniques can be divided in three categories. Primarily traction-based, e.g. Hippocrates, Milch, primarily leverage-based, e.g. Kocher and so-called "biomechanical" techniques, e.g. scapular manipulation, FARES, modified Milch and Cunningham.[4–8]

Worldwide, Emergency Departments are increasingly busy and overcrowded, leading to increased "door-to-provider" times and prolonged ED throughput times. The overall mean LOS for discharged patients in the Netherlands is 119 minutes.[9–11] A recent single centre Dutch hospital study showed that ED overcrowding occurred 30.8% of the time.[10] This is associated with negative patient outcomes, including treatment delays and a higher risk for adverse events.[9–11]

ASD patients often require significant ED resources, such as medications, materials, monitoring and attention by ED personnel, further impacting and lengthening ED LOS and potentially effecting waiting times for other patients.[6,8,12,13]

The present literature contains little on factors determining ED LOS for ASD patients. We therefore initiated this study to determine which factors influence ED LOS for ASD patients. We postulated that reduction method, medication use, patient age and patient dislocation history (primary vs. recurrent) would influence LOS.

METHODS

Study data was collected from *Westfriesgasthuis (WFG)* in Hoorn, and the *Flevoziekenhuis (Flevo)* in Almere, the Netherlands. These two community EDs have approximately 50,000 visits a year combined. WFG is a level two trauma center with 14 rooms at the ED and provides a training program for Emergency Medicine residents. Flevo is a level three trauma center, with

16 rooms and without an Emergency Medicine residents training program. Ethics committee approval was obtained at both facilities.

Using the DBC-code, 'Diagnose-Behandel-Combinatie', meaning Diagnosis Treatment Combination, for "shoulder dislocation" we identified all the patients that visited the ED at WFG and Flevo Hospital between January 2010 and July 2016. The DBC is a unique code used in the Netherlands to identify certain combinations of diagnosis and treatment. In Flevo the orthopedic and surgical department have a weekly schedule in supervising the ED and because of administrative issues we only included those patients that were seen for the orthopedic department. The medical records were checked to only include the anterior shoulder dislocations, i.e. other directions of dislocation were excluded. Other exclusion criteria were age younger than 12 years, reduction before arrival at the ED and patients presenting after multi-trauma or other health issues that made the ASD not the first priority of treatment. Repeated presentations of the same patient were recorded as different cases.

The patient characteristics were extracted from the electronic patient records (WFG; HiX version 6.0 HF55, manufactured by ChipSoft BV, Amsterdam and Flevo; i.s.h.med, manufactured by Cerner Corporation, North Kansas City). Data and statistical analysis were managed with IBM SPSS Statistics, version 20 for MacOSX. Continuous variables were compared for subgroups with the non-parametric Kruskall-Wallis H test and the Mann-Whitney U Test. The Pearson Chi-square test was used for evaluating differences between groups in categorical variables. Testing for normality was done with the Kolmogorov-Smirnov test. Numerical data are presented with median and interquartile range (IQR). As a cut-off point for significance, a p-value of 0.05 was used.

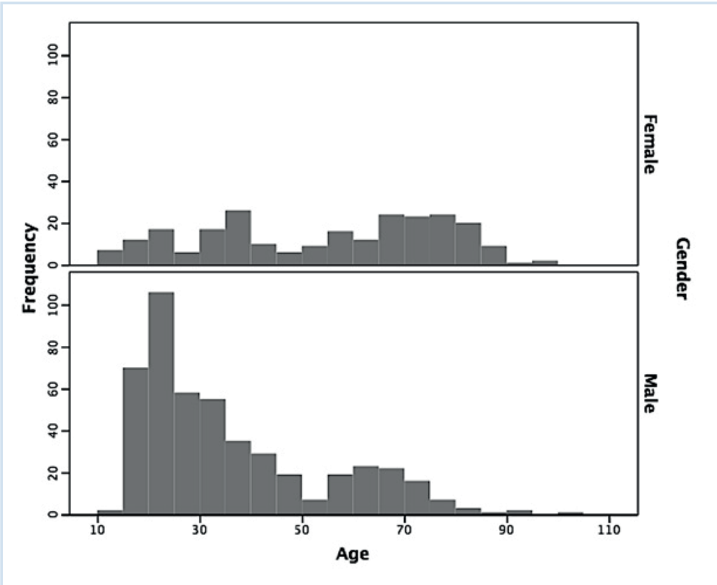
All medical record inconsistencies (e.g. radiograph interpretation discordance) were discussed by a panel consisting of the lead researcher, an emergency medicine resident and an emergency physician. Only panel consensus findings were used in these cases. The first author performed all data collection and 10% of this data was checked for reliability by the panel.

RESULTS

Records for 716 ASD occurring in 574 patients were available for analysis. Primary (first time) ASD numbered 389 (54.3%) and 327 (45.7%) were recurrent (more than one same-sided) ASD. Males sustained 475 (66.3%) of the ASD. There was a trimodal age distribution, with peaks at 21, 43 and 65 years.

The overall median age was 35 years (IQR 39). The median age for males was 30 years (IQR 23) and 59 years (IQR 39) for females (Figure 1). This difference in age was significant ($p<0.001$). Recurrent ASD occurred in younger individuals (median age 28 years, IQR 17) compared with primary ASD (median age 48 years, IQR 38) ($p<0.001$).

Figure 1: age distribution



The most common ASD mechanisms were falls (34.1%), sports (25.0%) and non-traumatic causes (23.0%). Primary dislocations most commonly resulted from falls. Most recurrent dislocations were non-traumatic (Table 1).

In fall-related ASD, more than half the patients were older than 55. In sports-related ASD nearly ¾ (72.6%) of the patients were under the age of 35 (Table 1). ASD due to falls occurred in significantly older patients compared with other dislocation causes, with a median age of 61 years (IQR 35) ($p<0.001$).

Sports-related dislocations occurred in younger patients compared to non-traumatic causes ($p=0.011$), traffic ($p<0.001$), and falls ($p<0.001$) with the median age being 26 years (IQR 17).

First attempt reduction methods are listed in table 2, with the most popular being the Cunningham method and traction-countertraction methods (which includes the Hippocrates method and the Stimson technique).

Table 1: Mechanisms of dislocation regarding to being a primary or recurrent dislocation and regarding to age

Mechanism of dislocation	Median age (IQR)	Primary N=389 % of primary	Recurrent N=327 % of recurrent	Total N=716 % of total	<35 yrs	36-55 yrs	56-75 yrs	>75 yrs
Non-traumatic	28 (22)	14 3.6%	151 46.2%	165 23.0%	109 66.1%	25 15.2%	23 13.9%	8 4.8%
Sports	26 (17)	94 24.2%	85 26.0%	179 25.0%	130 72.6%	32 17.9%	15 8.4%	2 1.1%
Traffic	46 (44)	45 11.6%	9 2.8%	54 7.5%	21 38.9%	12 22.2%	16 29.6%	5 9.3%
Fall	61 (35)	194 49.9%	50 15.3%	244 34.1%	52 21.3%	50 20.5%	98 40.2%	44 18.0%
Epileptic insult	33 (11)	5 1.3%	8 2.4%	13 1.8%	9 69.2%	3 23.1%	1 7.7%	0 0.0%
Other	26 (17)	37 9.5%	24 7.3%	61 8.5%	42 68.9%	12 19.7%	7 11.5%	0 0.0%
Total	35 (39)	389 54.3%	327 45.7%	716 100%	363 50.7%	134 18.7%	160 22.3%	59 8.2%

Table 2: Reduction methods used

Reduction method;	Frequency	Percent
Unknown	363	50.7
Cunningham	114	15.9
Traction-countertraction	113	15.8
Milch	81	11.3
Kocher	22	3.1
Scapular Manipulation	17	2.4
Other	6	0.8
Total	716	100

There was a total of 360 associated injuries, occurring in 287 patients. A Hill Sachs lesion was the most common associated local injury (198/716, 27.7%), followed by Bankart's lesion (58/716, 8.1%) and greater tubercle fractures (45/716, 6.3%) (Table 3). There was a significant difference in age with greater tubercle fractures ($p<0.001$), subcapital humerus fractures ($p=0.015$), nerve damage ($p=0.008$) and damage to the rotator cuff muscles ($p<0.001$), all being more common in the elderly. Although 52.0% of the Hill Sachs lesions occurred in patients under the age of 35, we did not find a significant difference in age ($p=0.253$).

Table 3: Associated injuries

	N	% of patients
No associated injuries	429	59.9
Hills Sachs lesion	198	27.7
Bankart's lesion	58	8.1
Tuberculum majus fracture	45	6.3
Subcapital humerus fracture	4	0.6
Nerve damage	25	3.5
Vascular damage	0	0.0
Muscle rupture	30	4.2
Total number of associated injuries	360	
Total patients with associated injuries	287	40.1
Total patients	716	100

Reduction methods based on traction-counter traction and leverage were used in 135 of the cases. Biomechanical techniques were used in 212 cases. In 369 (51.5%) cases the reduction method used was not specified.

Medication use (opiates, benzodiazepines, procedural sedation and analgesia, intra-articular lidocaine) differed significantly with reduction methods used. In 33% (n=70) of biomechanical reductions, no medications were used. When traction-countertraction or leverage techniques were employed, a non-medication approach occurred in only 16.3% (n=22) of cases ($p<0.01$).

The median length-of-stay (LOS) was 92 minutes (IQR 66). The LOS was not obtainable from 16 charts. LOS differed significantly between recurrent and primary ASD ($p<0.001$), the median LOS being 78 minutes (IQR 54.5) for recurrent dislocations and 102 minutes (IQR 68) for primary dislocations.

LOS differed significantly between patients given ED medications to facilitate reduction and those not given medications, with a median LOS of 99 minutes (IQR 67) for the medicated group compared to a LOS of 61 minutes (IQR 60) for the un-medicated group ($p<0.001$). There was also a significant difference in LOS for those who received procedural sedation and analgesia, median 139 minutes (IQR 89) and those who received other kinds of analgesia, median 90 minutes (IQR 54.0) ($p<0.001$) (Table 4).

Table 4: Length of Stay in minutes

	N	Median (IQR)
Total	700	92.0 (65.75)
Recurrent dislocation	321	78.0 (54.5)
Primary dislocation	379	102.0 (68.0)
Medication		
No prescription drugs administered	159	61.0 (60.0)
Any kind of prescription drugs administered	541	99.0 (67.0)
- Medication administered (excl. PSA)	396	90.0 (54.0)
- PSA administered	143	139.0 (89.0)
Age		
< 35 yrs	249	88.0 (57.0)
36 – 55 yrs	104	92.5 (62.8)
56 – 75 yrs	137	110.0 (79.5)
>75 yrs	51	134.0 (100.0)

Prescription drugs; i.e. opiates, benzodiazepines, intra-articular lidocaine, or PSA (Procedural Sedation and Analgesia).

We classified the cases in age-groups to determine the effects of age (<35, 36-55, 56-75 and >75yrs). The LOS was longer for the more elderly compared to the younger ones. This difference was significant in both the overall population as in the recurrent or primary dislocation groups (Table 4).

When we compared the LOS for the different kind of reduction methods used, we did not find any significant differences ($p>0.05$). The ED LOS was not influenced by the ASD reduction method used.

DISCUSSION

We found a trimodal age distribution with the peaks at 21, 43 and 65 years. The median length of stay was 92 minutes (IQR 66) and was longer for the elderly, in those with primary dislocations and in those cases in which medication was administered. Other literature generally describes a bimodal age distribution.[14–16] In younger patients, sports were the main cause leading to dislocation, while in elderly it mostly occurred due to a fall.

Our incidence of Hill Sachs lesions, Bankart's lesions and greater tubercle fractures were similar to other series.[14,17–19] Our study recorded a 3.5% nerve injury incidence, which is much lower than the reported incidence of 12-21% in other studies.[5,29,33] This could be due to underreporting or our focus on ED records only, since some nerve injury presentations are delayed. Some of our patients may have had follow up at other hospitals also leading to missing data on associated injuries.

ASD is a stressful painful experience. It has been suggested that successful reduction depends primarily on local muscle relaxation.[12,20] For this reason, analgesic, anesthetic or sedating agents are often administered. Procedural sedation and analgesia (PSA) effectively provides muscular relaxation and pain relief but confers a substantial side effect risk and generally requires more resources and prolonged ED lengths of stay.[6,12,21,22] The administration of PSA is related to a longer LOS but also with a higher risk of complications compared to other kinds of medication.[6,12,21] In our series we found that the LOS for those who did not receive any kind of medication was 61 minutes compared to 99 minutes for the ones who got any kind of medication. Patients receiving PSA had a significantly longer ED LOS, over one hour longer when compared to un-medicated patients and more than 40 minutes longer when compared to those who received other kinds of medication, not being PSA.

The availability to make X-rays at the ED is an important factor for the LOS. Both the WFG as the Flevo have a dedicated room for making X-rays for the emergency department, but the radiological technician making the x-rays can also be busy with operating the CT-scanner during evening and night shifts. So maybe hospitals with more capacity, facilities or staff might provide shorter LOS, but some delay will always be a part of the day-to-day routine of an emergency department.

LIMITATIONS

Our study is a retrospective chart review, therefore uncontrolled. Patient evaluation and treatment was performed according to individual physician preference. Some data, like individual physician experience, physician workload, ED census at a given time and a variety of other information which may impact physician decision making or approach, are not obtainable from electronic health records and are therefore not considered. In the *WFG* there is an Emergency Medicine residency training program, while the *Flevo* does not have this program. This could have led to a different treatment approach or more delay in treatment. For the *Flevo* we only included the patients when the orthopedic department was on call (they alternate every other week with the surgical department), leading to an incomplete view of the patients that visited the ED.

Patient characteristics were abstracted from electronic health records, which are not designed for research purposes. Factors like patient build, comorbidities and time from presentation to reduction, all of which could influence LOS, could not be retrieved from available health records.[21,23] Some data, like trauma mechanism and reduction methods used had to be abstracted from written medical history, which could have resulted in incomplete and inconsistent registration, which could skew our results. In 61/716 (8.5%) records the mechanism of trauma could not be fully defined.

We found no significant correlation between reduction methods used and LOS, although the reduction method was unknown in 51.5% of cases. It might be that only successful reduction methods were recorded and failed reduction methods omitted. The number of attempts and the time needed for the reduction itself were not recorded either.

CONCLUSION

To our knowledge this is the largest chart review focused on the length of stay at the emergency department (ED) for patients with an anterior shoulder dislocation.

In our study the median length of stay at the ED of patients with an anterior shoulder dislocation was 92 (IQR 66) minutes. An increased length of stay was found in patients with a primary dislocation, elderly patients and in those given any kind of medication before or during reduction. The administration of medication could lengthen the stay with more than 30 minutes.

We also found that medications were much more likely to be given to those undergoing traction-countertraction or leverage-based techniques, such as Hippocrates and Kocher, compared to biomechanical reduction techniques, such as scapular manipulation, Cunningham and (modified) Milch (84 vs 67%).

ED crowding and resultant prolonged lengths-of-stay are increasing worldwide. In case of the commonly seen anterior shoulder dislocation little can be done about patient characteristics. Our results suggest that ED LOS in this patient category can be significantly reduced if anterior shoulder dislocations are treated with reduction techniques that minimize medication use, especially procedural sedation and analgesia.

Development of an evidence based algorithmic approach to ASD reduction starting with, and focused on, pain-minimizing techniques is warranted.

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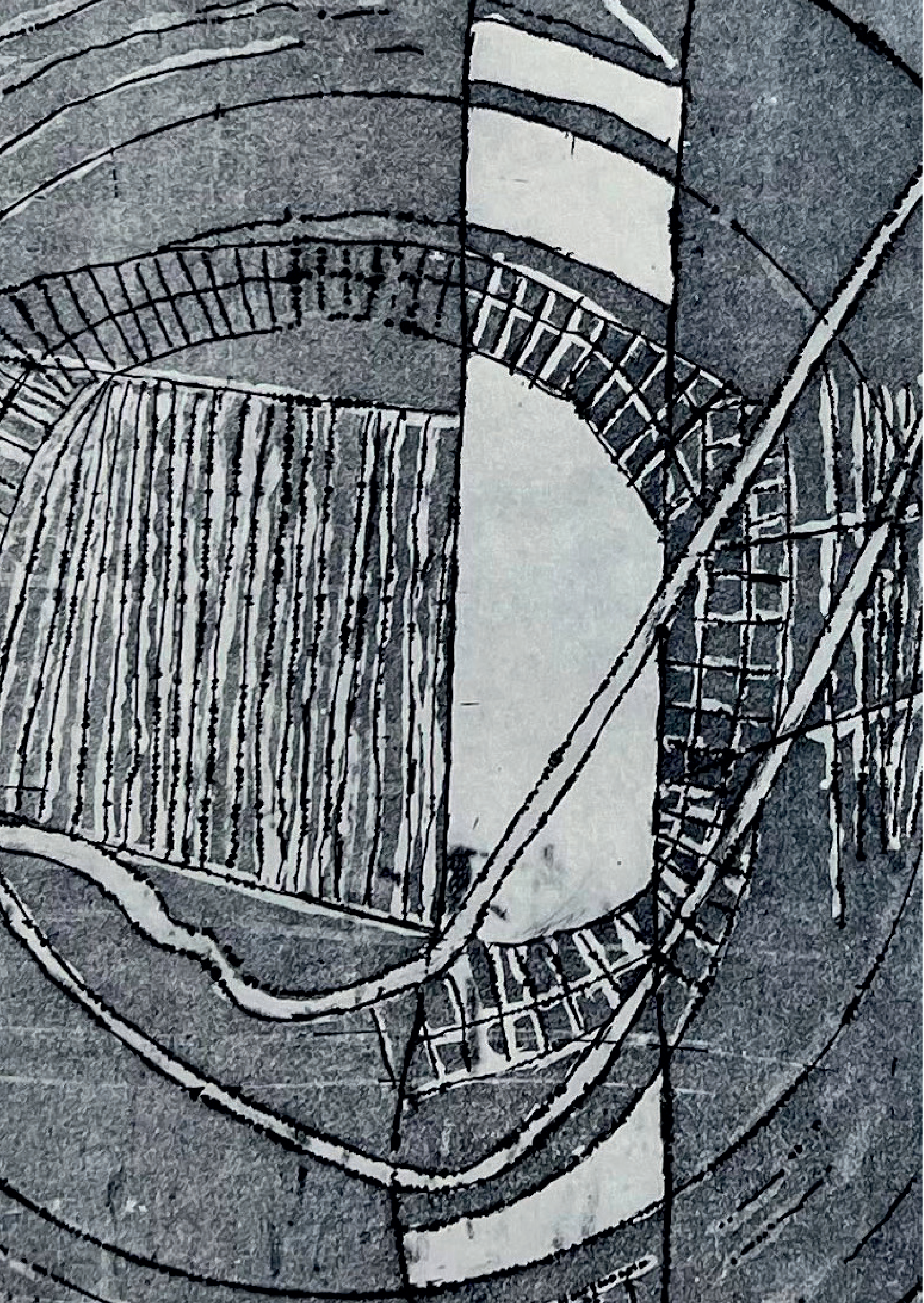

CHAPTER FIVE

Effects of reduction technique for acute anterior shoulder dislocation without sedation or intra-articular pain management: a systematic review and meta-analysis

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ABSTRACT

Introduction

Anterior shoulder dislocations are commonly seen in the emergency department for which several closed reduction techniques exist. The aim of this systematic review is to identify the most successful principle of closed reduction techniques for an acute anterior shoulder dislocation in the emergency department without the use of sedation or intra-articular lidocaine injection.

Methods

A literature search was conducted up to 15-08-2022 in the electronic databases of PubMed, Embase and CENTRAL for randomized and observational studies comparing two or more closed reduction techniques for anterior shoulder dislocations. Included techniques were grouped based on their main operating mechanism resulting in a traction-counter traction (TCT), leverage and biomechanical reduction technique (BRT) group. The primary outcome was success rate and secondary outcomes were reduction time and endured pain scores. Meta-analyses were conducted between reduction groups and for the primary outcome a network meta-analysis was performed

Results

A total of 3118 articles were screened on title and abstract, of which 9 were included, with a total of 987 patients. Success rates were 0.80 (95%CI 0.74; 0.85), 0.81 (95%CI 0.63; 0.92) and 0.80 (95%CI 0.56; 0.93) for BRT, leverage, and TCT, respectively. No differences in success rates were observed between the three separate reduction groups. In the network meta-analysis, similar yet more precise effect estimates were found. However, in a post-hoc analysis the BRT group was more successful than the combined leverage and TCT group with a relative risk of 1.33 (95%CI: 1.19, 1.48).

Conclusion

All included techniques showed good results with regards to success of reduction The BRT might be the preferred technique for the reduction of an anterior shoulder dislocation, as patients experience the least pain and it results in the fastest reduction.

INTRODUCTION

Anterior shoulder dislocations are the most frequently seen large joint dislocations in the emergency department (ED) with an incidence close to 23 in 100.000 person-years [1,2]. The dislocation is often the result of a sports injury or domestic falls [1,3]. The age distribution has two peaks, one for men around 30 years and for women around 50 years of age [2,4]. Recurrence within 5 years of a shoulder dislocation occurs in 19-26% of the patients, most commonly in patients younger than 25 years old [2,3].

In daily clinical practice, a wide variety of closed shoulder reduction techniques is being used, the choice of which seems to be determined by physician's preference [5,6]. In general, reduction techniques can be categorized based on their main principle being (1) traction, (2) leverage and (3) techniques based on biomechanical principles [7]. In a survey in 2003 among surgeons working in Dutch EDs, the Hippocratic (traction-counter traction), Kocher (leverage) and Stimson (traction-counter traction) techniques were the most frequently used [8]. In a repeat survey in 2016 among Dutch emergency physicians, the Hippocratic and Kocher technique were still frequently used [9]. However, also biomechanical techniques such as Milch [10] and Cunningham [11] were increasingly reported.

Most present studies did not directly compare multiple techniques, but instead describe the success rate of a single technique, which makes comparisons between techniques difficult [11–15]. Furthermore, in studies that compare reduction techniques, often different forms of sedation (mostly benzodiazepines) or intra-articular lidocaine injection (IAL) are applied, limiting the direct comparability between studies [16–19].

So far, no systematic review or meta-analysis has been conducted that compares the three groups of reduction techniques (traction-counter traction, leverage or biomechanical) comparing only the technique with exclusion of the use of sedation or IAL. Therefore, the aim of this study was to identify the most effective group of closed reduction techniques for an acute anterior shoulder dislocation without the use of sedation nor IAL in the emergency department.

MATERIALS AND METHODS

Eligibility criteria

Randomized and observational studies of patients 16 years and older with an acute anterior shoulder dislocation that compared two or more closed reduction techniques from a different principle of action were included. The reduction techniques had to be well-defined, performed without the use of sedation (benzodiazepine, ketamine, propofol or etomidate), opiates in a more than normal analgesic dose or intra-articular pain management in the emergency department, and studies should compare the reduction success rates. Articles were included if written in English or Dutch. Excluded were letters, comments, abstracts for conferences, case reports, study protocols, reviews, biomechanical studies, animal studies or are non-hospital based (wilderness medicine, ski resorts) and noncomparative studies. The study protocol was not registered. This study was reported according to PRISMA guideline for systematic review 2020.

Search strategy

The search query that was used is provided in Appendix 1. Three reviewers (DB, MV and MR) independently searched the PubMed (including MEDLINE), Embase, and CENTRAL (Cochrane Central Register of Controlled Trials) electronic databases up to 15-08-2022**.** Disagreement regarding eligibility was resolved by discussion between the reviewers (DB, MV and MR).The identified records were first screened based on title and abstract and potentially suitable articles were read full text. The references of the included studies were screened for eligibility, and citation tracking was performed by using Web of Science to identify articles not found in the original search. In case no full-text version of the article was available, the corresponding authors were contacted by email and in case of no response, one reminder email was sent.

Data extraction

For each study, data extraction was performed independently by three reviewers (DB, MV and MR), after which the results were compared and discussed. There was no disagreement between reviewers. The following items were extracted: first author, year of publication, study design, country or countries in which the study was performed. In addition, the following information was extracted stratified by reduction technique: number of included patients, number of dislocations, proportion of female patients, mean age of included patients, dominant arm, pre-reduction fractures, primary dislocations, reduction success first reduction, reduction time, length of stay in the ED, Visual Analogue Scale (VAS) or Numeric (pain) Rating Scale (NRS), before, during and after reduction, and complications of the reduction.

Classification of reduction techniques

A wide range of reduction techniques is described in the literature. Techniques can be classified based on their main principle of action: traction-counter traction (TCT – e.g. Hippocratic, Chair, Spaso, Matsen, Stimson, Davos, Traction-Countertraction), leverage (e.g. Kocher, External rotation) or biomechanical reduction technique (BRT – e.g. Scapular manipulation technique, (modified) Milch, FARES, Cunningham) [5,7].

Outcome measures

The primary outcome was defined as the percentage of successful reductions in each of the three groups (TCT, leverage, and BRT). The secondary outcome measures were time to reduction, ED length of stay, patient reported pain score pre-, during and after reduction, and the number and type of complications.

Quality assessment

Three reviewers (DB, MV and MR) assessed every article independently regarding the methodologic quality using the Methodological Index for Non-Randomized Studies (MINORS) [20]. The MINORS is a validated instrument for assessment of methodologic quality and reporting of observational studies of surgical interventions [20]. Further details on the MINORS criteria and scoring system are provided in Appendix 2. Disagreements were resolved by discussion between the reviewers (DB, MV and MR).

Statistical analyses

Information about continuous outcome measures was converted to means and standard deviations when sufficient information was available using methods described in the Cochrane Handbook for Systematic Reviews of Interventions [21]. For each technique the probability of treatment success was estimated using a random effects model that pooled information across different studies. For each technique information was included directly from studies that reported on that technique. The function metaprop of the R package meta was used. For each pairwise comparison between reduction techniques a meta-analysis was performed, which included only studies in which the relevant comparison was made. The computer program Review Manager (RevMan), Version 5.4.1, was used [22]. All analyses were performed stratified by study design (i.e., RCTs and observational studies separately) as well as all study designs combined. Results of different studies were pooled by means of a random-effects model, using inverse variance weighting methods. In addition, for the primary outcome a network meta-analysis was performed in which the pairwise information is combined in a network that allows for simultaneous estimation of the effects of the three pairwise comparisons. The network meta-analysis was performed using the netmetabin function from the netmeta package in the statistical software package R.

For binary outcome measures are presented as risk ratios (RRs) with 95% confidence intervals (CIs). For continuous outcome measures, results are presented as differences in means with corresponding 95% CIs. Heterogeneity between studies was assessed by visual inspection of the forest plots and by estimating statistical measures for heterogeneity, that is, the Tau^2 statistic and the χ^2 statistic. Inspection of a funnel plot of the primary outcome measure against its standard error was done to detect potential publication bias.

RESULTS

Figure 1 shows a flow chart of the literature search, which resulted in 9 studies [23–31] being included for review and meta-analysis. There were 5 RCT's, 3 prospective studies and 1 retrospective study. In the study of Guler, et al. [26] four different techniques are compared, of which three were traction-counter traction. For the present study the group treated with the Spaso technique was included in the meta-analysis, because this technique is also used in other studies. Inclusion of all three techniques would overrepresent the Guler study in the meta-analysis. For the secondary outcomes of ED length of stay and patient reported pain score before and after reduction there was too little data to perform a meta-analysis.

Quality assessment

Regarding the different MINORS criteria, all studies had a maximum score for 'clearly stated aim' and 'contemporary groups', except for one. Regarding 'unbiased assessment of the study endpoint', only three studies scored one point and the other studies scored no points. Agreement with the MINORS criteria per study can be found in Appendix 3. The full MINORS criteria were not met by any of the included studies.

Baseline characteristics of study participants

Information about the studies and characteristics of patients included in the meta-analysis can be found in Table 1. The nine studies included in the meta-analysis comprised a total of 987 patients. There were 273 patients in the biomechanical group, 336 in the traction-counter traction group and 378 in the leverage group. The mean age was 38,6 years and 315 of the 987 (31.9%) patients were female. The number of dislocations was the same as the number of patients included. Arm dominance was reported in two studies, pre-reduction fractures were reported in four studies and previous dislocations status was reported in three studies, so no comparison could be made for these outcomes [23,25–28,31].

Figure 1: Flow diagram of selection of articles for meta-analysis

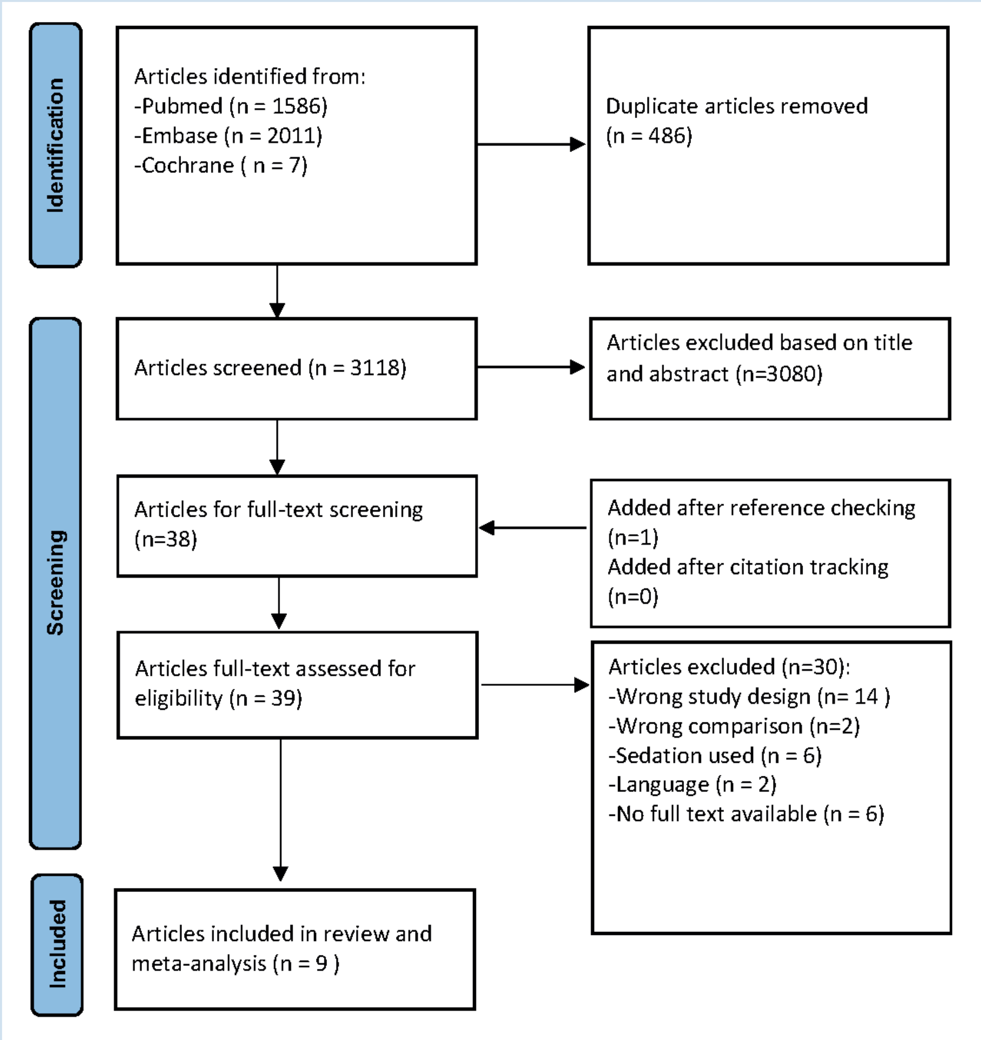


Table 1: Characteristics of studies included in systematic review and meta-analysis of reduction techniques for shoulder dislocation

Study	Study design	Country	Treatment groups	Technique	No. of patients	Mean age yr	Female/male patients
Adhikari, 2018[23]	PC	Nepal	Biomechanical	Scapular manipulation	23	36	4/19
			Leverage	External rotation	23	36	6/17
Amar, 2021[27]	RCT	Israel	Biomechanical	Milch	35	44	9/26
			Traction-counter traction	Stimson	25	43	4/21
Beattie, 1986 [24]	PC	Scotland (UK)	Biomechanical	Milch	56	53	NR
			Leverage	Kocher	55	53	NR
Guler, 2015 [26]	RC	Turkey	Leverage	Kocher	40	34	9/31
			Traction-counter traction	Spaso	39	39	7/32
Maity, 2012 [28]	RCT	India	Biomechanical	FARES	80	37	15/65
			Leverage	External rotation	80	36	17/63
Rezende, 2015 [29]	RCT	Brazil	Leverage	Kocher	43	31	7/36
			Traction-counter traction	Spaso	45	30	6/39
Sapkota, 2015 [30]	RCT	Nepal	Biomechanical	Milch	26	27	9/26
			Leverage	External rotation	26	28	11/15
Sayegh, 2009 [31]	RCT	Greece	Biomechanical	FARES	53	41	10/43
			Traction-counter traction	Traction-counter traction	51	46	10/41
			Leverage	Kocher	50	44	13/37
Turturro, 2014[25]	PC	Italy	Leverage	Kocher	61	40	15/46
			Traction-counter traction	Traction-counter traction	176	43	52/124

RCT, randomized controlled trial; *PC*, prospective cohort study; *RC* retrospective cohort study; *NR*, not reported

Reduction success

For all three groups high success rates were reported, i.e., 0.80 (95%CI 0.74; 0.85), 0.81 (95%CI 0.63; 0.92) and 0.80 (95%CI 0.56; 0.93) for BRT, leverage, and TCT, respectively. Pairwise meta-analysis of within-study comparisons between techniques did not reveal statistically significant differences in reduction success between the groups of reduction techniques: BRT vs Leverage 1.20 (95%CI 0.93, 1.55), BRT vs TCT 1.83 (95%CI 0.66, 5.05), and TCT vs Leverage 1.01 (95%CI 0.87, 1.18), see Figure 2,3 and 4. Meta-analysis stratified by study design did not lead to different conclusions.

Figure 2: Reduction success of biomechanical versus leverage techniques for treatment of shoulder dislocation

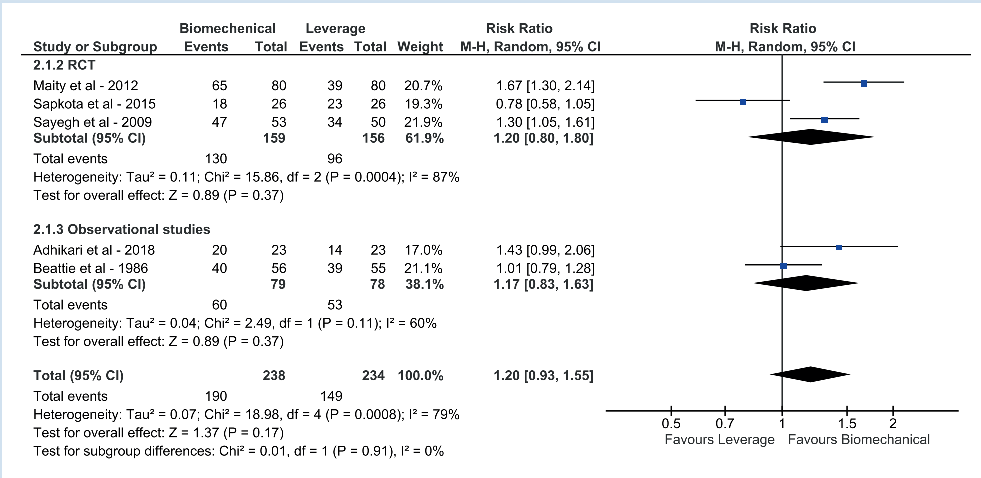


Figure 3: Reduction success of biomechanical versus traction-counter traction techniques for treatment of shoulder dislocation

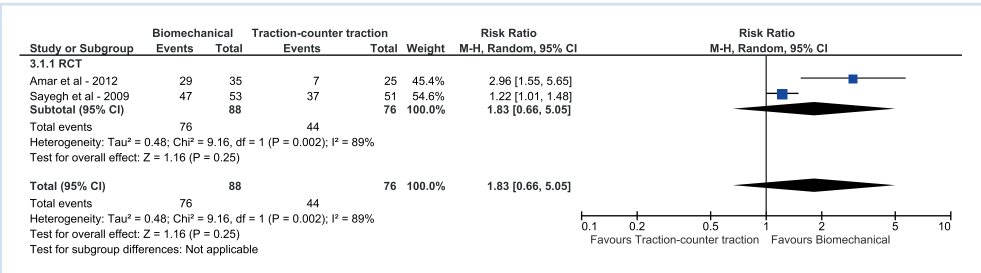
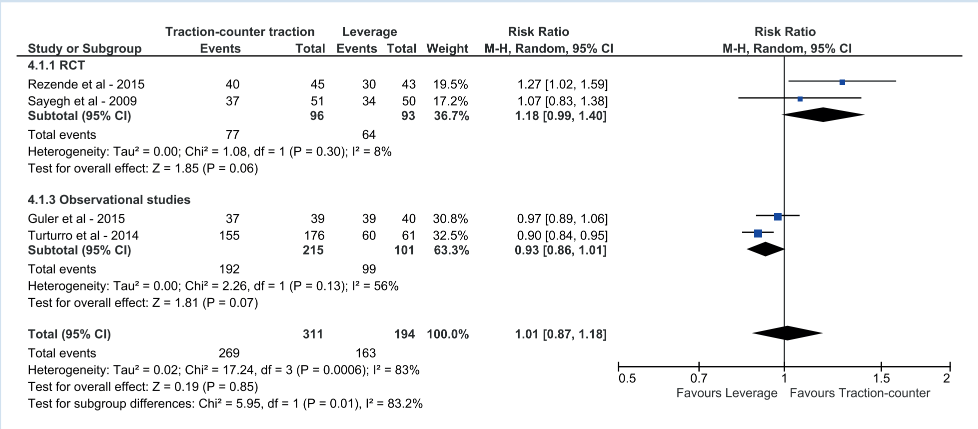


Figure 4: Reduction success of traction-counter traction versus leverage techniques for treatment of shoulder dislocation



In the network meta-analysis, similar yet more precise effect estimates were found: BRT vs Leverage 1.25 (95%CI 1.05, 1.48), BRT vs TCT 1.28 (95%CI 1.04, 1.59), and TCT vs Leverage 0.97 (95%CI 0.82, 1.15).

The relative risk of the comparison of leverage and TCT was only 1.01. Therefore, we did a post-hoc analysis comparing the BRT group with the TCT and leverage groups combined, which showed a positive effect for BRT with a 33% increased probability of success, RR 1.33 (95%CI: 1.19, 1.48), see Figure 5. Again, stratification by study design did not change the results. The symmetry in the funnel plot in Figure 6 did not reveal a possible publication bias.

Patient reported pain during reduction

All studies reported pain using a VAS score. Pooled results comparing reported pain were in favor of BRT versus leverage, with a difference in VAS of -2.76 (95%CI: -4.16, -1.36). In the BRT versus TCT the difference in VAS was -0.34 (95%CI: -0.61, -0.08). Comparison between TCT versus leverage showed no difference in VAS 0.05 (95%CI:: -0.25, 0.35), see table 2.

Table 2: Pain experience by patients (VAS) during the treatment of a dislocated shoulder stratified by reduction technique

Comparison	Number of studies	Total number of Participants	Mean difference in VAS (95% CI)
BRT vs leverage	3	309	-2.76 (-4.16, -1.36)
BRT vs TCT	2	164	-0.34 (-0.61, -0.08)
TCT vs leverage	3	268	0.05 (-0.25, 0.35)

BRT, biomechanical reduction technique; *TCT*, traction-counter traction technique

Figure 5: Reduction success of biomechanical versus either traction-counter traction or leverage techniques for treatment of shoulder dislocation

Study or Subgroup	Biomechanical Events	Biomechanical Total	Other techniques Events	Other techniques Total	Weight	Risk Ratio M-H, Fixed, 95% CI
5.1.1 RCT						
Amar et al - 2012	29	35	7	25	4.7%	2.96 [1.55, 5.65]
Maity et al - 2012	65	80	39	80	22.6%	1.67 [1.30, 2.14]
Sapkota et al - 2015	18	26	23	26	13.3%	0.78 [0.58, 1.05]
Sayegh et al - 2009	47	53	71	101	28.3%	1.26 [1.08, 1.48]
Subtotal (95% CI)		**194**		**232**	**69.1%**	**1.42 [1.24, 1.62]**
Total events	159		140			
Heterogeneity: Chi² = 24.66, df = 3 (P < 0.0001); I² = 88%						
Test for overall effect: Z = 5.19 (P < 0.00001)						
5.1.2 Observational studies						
Adhikari et al - 2018	20	23	14	23	8.1%	1.43 [0.99, 2.06]
Beattie et al - 1986	40	56	39	55	22.8%	1.01 [0.79, 1.28]
Subtotal (95% CI)		**79**		**78**	**30.9%**	**1.12 [0.92, 1.36]**
Total events	60		53			
Heterogeneity: Chi² = 2.49, df = 1 (P = 0.11); I² = 60%						
Test for overall effect: Z = 1.10 (P = 0.27)						
Total (95% CI)		**273**		**310**	**100.0%**	**1.33 [1.19, 1.48]**
Total events	219		193			
Heterogeneity: Chi² = 27.44, df = 5 (P < 0.0001); I² = 82%						
Test for overall effect: Z = 5.03 (P < 0.00001)						
Test for subgroup differences: Chi² = 3.85, df = 1 (P = 0.05), I² = 74.0%						

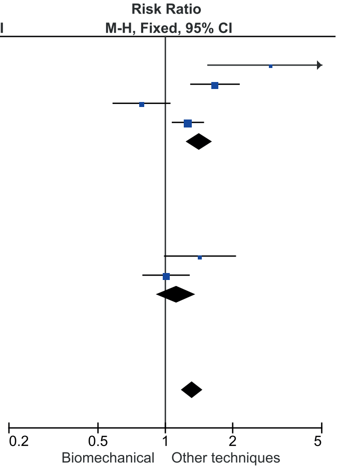
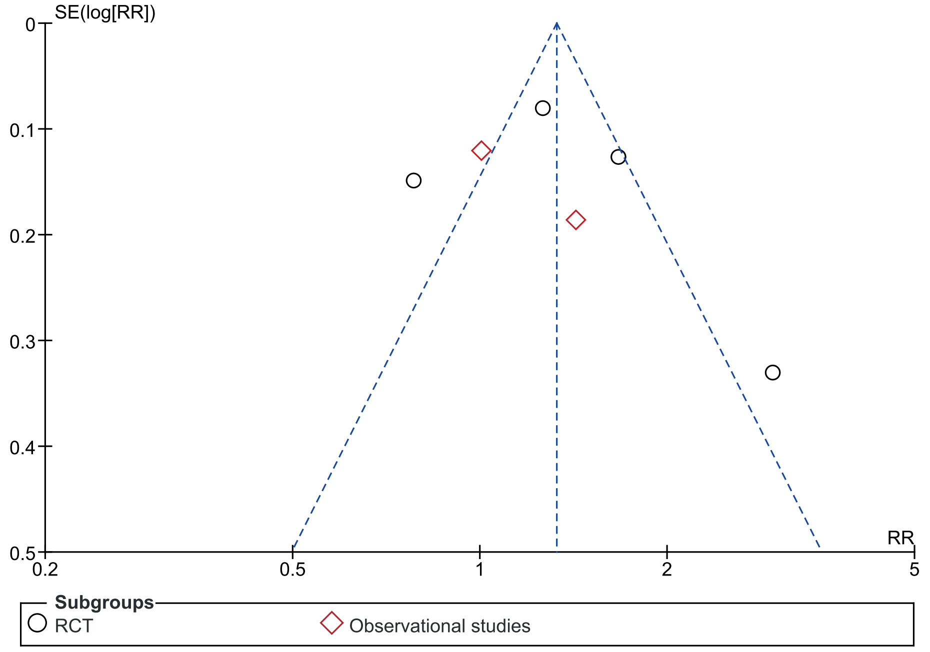


Figure 6: Funnel plot of reduction success biomechanical versus traction-counter traction and leverage



Reduction time

The time to reduction in the BRT group was 53 seconds faster compared to the leverage group (95%CI: -76, -30). Between BRT versus TCT this difference was 194 seconds (95%CI: -226, -161). The time to reduction in the TCT group was 96 seconds faster compared to the leverage group (95%CI: -110, -82), see table 3.

Table 3: Difference in mean reduction time in the treatment of a dislocated shoulder stratified by reduction technique

Comparison	Number of studies	Total number of participants	Mean difference in seconds (95%CI)
BRT vs leverage	3	315	-53 [-76, -30]
BRT vs TCT	2	164	-194 [-226, -161]
TCT vs leverage	4	505	-96 [-110, -82]

BRT, biomechanical reduction technique; *TCT,* traction-counter traction technique

Complications

Just one complication was reported [24]. An 83-year-old lady suffered a spiral fracture of the humerus during reduction using the Kocher (leverage) technique.

DISCUSSION

The aim of this study was to compare reduction success of three groups of closed reduction techniques for acute anterior shoulder dislocation, applied at the emergency department and without the use of sedation or IAL. For all three groups high success rates were reported, however none of the individual group of techniques was found to be superior, compared to the others.

In addition to success rate, several secondary outcomes were studied. Reduction was less painful in the BRT group when compared with both leverage (-2.76, 95%CI -4.16, -1.36) and TCT (-0.34, 95%CI -0.61, -0.08]), where a difference in the MRS of 1.5 is considered clinically relevant [32,33]. Furthermore, BRT was found to be a technique that required less time than both TCT and leverage. However, it is questionable whether a difference of 53 seconds is of clinical relevance, nonetheless for patients experiencing enormous pain rapid relief could be valuable.

In the post-hoc analysis the BRT group was compared with a group in which the TCT and leverage groups combined. This analysis suggested that BRT is the best techniques for a successful and quick reduction of an anterior shoulder dislocation with the least reduction pain and with a low risk of complications.

The results of this meta-analysis is in agreement with the systematic review of Alkaduhimi et al., who also included studies with sedation and suggested that BRT (specifically SMT and FARES) are the best reduction techniques [6]. Also an earlier systematic review by Cunningham came to this conclusion [5]. In the meta-analysis by Dong et al, the conclusion was that almost all techniques seemed to have high success rates with low complication rates [34]. Dannenbaum et al. did a review were they concluded that there was no clear superior technique [35].

The difference between this meta-analysis and the ones mentioned above, is that it only included studies in which no advanced pain relief was used, such as sedation or IAL. Advanced pain relief techniques can ensure that the patient relaxes his musculature and therefore the technique used for the reposition is of minor importance. Nevertheless, advanced pain relief techniques themselves can pose a risk since there is less control during the reposition for consequences of stretching of vulnerable structures. Another difference between this meta-analysis and previous ones is that this study grouped the techniques by mode of action, making it possible to compare a larger number of studies.

A strength of this meta-analysis is that this study included similar studies, in which sedation or IAL was not used. Furthermore, all outcomes (e.g., success rate, pain, and duration of techniques) that were considered are clinically relevant outcomes that are easy to interpret by treating physicians and by patients.

A limitation in this study is that the individual techniques could not be directly compared in separate meta-analyses, since for most separate techniques limited data were available. Therefore, this study does not provide evidence for the best individual technique, however this study could give direction to the best group of techniques. A second possible limitation is that the MINORS criteria were used to assess the methodological quality of the included studies. To assess the methodological quality of RCTs, the Cochrane Risk of Bias tool is commonly used. However, since our study included both RCTs and observational studies, and we aimed to assess their methodological quality with the same tool, we opted for the MINORS tool. Slim et al have been externally validated the MINORS for RCTs and found it to differentiate well between different study designs, with randomized trials scoring higher than well-designed non-randomized trials [20,36,37]. Another limitation that the number of included studies was limited, thus also limiting the power to detect publication bias using the funnel plot depicted in Figure 6. An additional limitation of this study is the limited number of studies included in each comparison and the heterogeneity in both the randomized and observational studies. Also, the wide range of years in which included studies were conducted may have influenced this study’s findings since emergency medicine has improved over the last years. However, again data were too limited to allow for separate analyses stratified by time period. Although this study’s outcome measures are of clinical importance, they may be of less relevance for individual patients. Length of stay (LOS) at the ED and total time to reduction possibly contribute more to a negative experience for patients, since quick reduction is suggested as the best way for quick pain relief [17,27]. Additionally, prolongation of time to reduction could decrease success of used technique, possibly due to increase of muscle spasms [38]. LOS and total time to reduction were scarcely reported and were therefore not compared

Future research

Future research should focus on comparing individual BRT techniques in an RCT to discover the most effective and efficient closed reduction technique, preferably without the use of sedation and/or IAL. It could also be of interest to analyze a single technique and focus on the effectiveness and risk of a reduction both with and without the use of sedation, possibly providing clarity on the influence and the added value of sedation, given that sedation or IAL takes up time which increases length of stay in an increasing busy emergency department [39,40]. Moreover, future research in individual techniques should include more outcomes that are directly of importance for patients such as LOS and time to reduction.

CONCLUSION

In summary almost all included techniques showed good results for reduction without sedation in the first attempt. This study might provide support that the BRT seems to be the preferred reduction technique in anterior shoulder dislocation, resulting in a rapid successful reduction with limited pain. Therefore, in daily practice and future research more focus should lie to the more patient-friendly and effective biomechanical reduction techniques.

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SUPPLEMENTAL MATERIAL

Appendix 1: Search query

Pubmed: (n=1586)

("anterior shoulder dislocation" OR "Shoulder Dislocation"[Mesh] OR forward shoulder luxation[Title/Abstract] OR forward glenohumeral dislocation[Title/Abstract] OR forward glenohumeral luxation[Title/Abstract] OR forward glenohumeral joint[Title/Abstract] OR forward shoulder dislocation[Title/Abstract] OR anterior shoulder dislocation[Title/Abstract] OR anterior shoulder luxation[Title/Abstract] OR anterior glenohumeral dislocation[Title/Abstract] OR anterior glenohumeral joint luxation[Title/Abstract] OR anterior glenohumeral luxation[Title/Abstract] OR anterior shoulder dislocation[Title/Abstract] OR anterior glenohumeral dislocation[Title/Abstract] OR ventral shoulder luxation[Title/Abstract] OR ventral glenohumeral dislocation[Title/Abstract] OR ventral glenohumeral joint luxation[Title/Abstract] OR ventral glenohumeral luxation[Title/Abstract] OR ventral shoulder dislocation[Title/Abstract] OR ventral glenohumeral dislocation[Title/Abstract])

AND

(treatment outcome[MeSH Terms] OR effectiveness, treatment[MeSH Terms] OR repositioning success rate[Title/Abstract] OR success rate[Title/Abstract] OR success[Title/Abstract] OR successful[Title/Abstract] OR successfulness[Title/Abstract] OR effectiveness[Title/Abstract] OR reduction technique[Title/Abstract] OR reduction method[Title/Abstract] OR reduce[Title/Abstract] OR relocat*[Title/Abstract] OR reposit*[Title/Abstract] OR repositioning techniques[Title/Abstract] OR biomechanical reposition techniques[Title/Abstract] OR leverage-based techniques[Title/Abstract] OR hippocratic method[Title/Abstract] OR kocher[Title/Abstract] OR acute shoulder reposition[Title/Abstract] OR scapular manipulation[Title/Abstract] OR closed reduction techniques[Title/Abstract] OR snowbird[Title/Abstract] OR cunningham[Title/Abstract] OR milch[Title/Abstract] OR eskimo technique[Title/Abstract] OR traction countertraction[Title/Abstract] OR Stimson[Title/Abstract] OR spaso[Title/Abstract] OR boss holzach matter[Title/Abstract])

Embase: (n=2011)

shoulder AND dislocation

reduct*

reposit*

#2 OR #3

#1 AND #4

#5 AND 'human'/de AND 'article'/it

Cochrane: (n=7)

Anterior shoulder dislocation

Appendix 2: Adapted MINORS criteria

Methodological items	2	1	0
A clearly stated aim	Aim or hypothesis including outcomes have been reported	Aim or hypothesis have been reported without a clear outcome	Not reported
Inclusion of consecutive patients	Explicit inclusion and exclusion criteria have been reported	Unclear or poor description inclusion and exclusion criteria have been reported	Not reported
Prospective collection of data Retrospective	Prospective with a description of the protocol	Prospective without a description of the protocol	Retrospective
Endpoints appropriated to the aim of the study	Outcomes are appropriate to the aim of the study	Outcomes are not appropriate to the aim of	Not reported
Unbiased assessment of the study endpoint	Blind evaluation of objective outcomes	Reason not blinded stated	Not reported
Follow-up period appropriate to the aim of the study	Emergency department visit	-	Not reported
Loss to follow up	All inclusions are the results reported or the exclusions described	Not all inclusions are the results reported and without described	Not reported
Prospective calculation of the study size	Power analysis has been performed	Explanation for the number of included patients without a power analysis	Not reported or not performed
An adequate control group	Having a intervention recognized as the optimal intervention according to the available published data	Not applicable	Not reported
Contemporary groups	Study group and controls have been managed during the same time period	Study group and controls have not been managed during the same time period	Not reported or unclear description
Baseline equivalence of groups	Adequate randomization and description	Baseline characteristics have been described	Not reported
Adequate statistical analyses	Statistical analysis has been described including the type of test	Inadequate statistical analysis	Not reported

5

Appendix 3: MINORS score per included study

Studie	Aim	Inclusion	Data	Endpoints	Unbiased	Follow-up	Loss to follow-up	Study size	Adequate control group	Contemporary groups	Baseline Equivalence of groups	Adequate statistical analyses	Total
Adhikari	2	2	2	2	0	2	2	0	2	2	0	2	**18**
Amar	2	2	2	2	1	2	2	0	2	2	2	2	**21**
Beattie	1	1	1	2	0	2	2	0	2	2	0	0	**13**
Guler	2	1	0	1	0	2	1	2	1	1	1	2	**14**
Maity	2	2	1	2	0	2	1	2	2	2	2	2	**20**
Rezende	2	2	2	1	1	2	2	2	2	2	1	2	**21**
Sapkota	2	1	1	2	0	2	2	0	2	2	1	1	**16**
Sayegh	2	2	2	2	1	2	2	2	2	2	2	2	**23**
Turturro	2	1	2	2	0	2	2	0	1	2	1	2	**17**

CHAPTER SIX

Biomechanical reposition techniques in anterior shoulder dislocation: a randomized multicenter clinical trial- the BRASD-trial protocol

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ABSTRACT

Introduction:

Glenohumeral (shoulder) dislocations are the most common large joint dislocations seen in the emergency department (ED). They cause pain, often severe, and require timely interventions to minimize discomfort and tissue damage. Commonly used reposition or relocation techniques often involve traction and/or leverage. These techniques have high success rates but may be painful and time consuming. They may also cause complications.

Recently, other techniques—the biomechanical reposition techniques (BRT)—have become more popular since they may cause less pain, require less time and cause fewer complications. To our knowledge, no research exists comparing the various BRTs.

Our objective is to establish which BRT or BRT combination is fastest, least painful and associated with the lowest complication rate for adult ED patients with anterior glenohumeral dislocations (AGDs).

Methods and Analysis:

Adults presenting to the participating EDs with isolated AGDs, as determined by radiographs, will be randomized to one of three BRTs - Cunningham, modified Milch or scapular manipulation.
Main study parameters/endpoints:
ED length-of-stay
Patients' self-report of pain
Secondary study parameters/endpoints:
Procedure times
Need for analgesic and/or sedative medications
Iatrogenic complications
Rates of successful reduction

Ethics and Dissemination:

Non-biomechanical AGD repositioning techniques based on traction and/or leverage are inherently painful and potentially harmful. We believe that the three BRTs used in this study are more physiologic, more patient-friendly, less likely to cause pain, more time efficient and less likely to produce complications. By comparing these three techniques we hope to improve the care provided to adults with acute AGDs by reducing their ED length-of-stay and minimizing pain and procedure-related complications. We also hope to define which of the three BRTs is quickest, most likely to be successful and least likely to require sedative or analgesic medications to achieve reduction.
Trial register: NTR5839

INTRODUCTION

We observed that commonly used AGD repositioning techniques using traction and/or leverage inflicted pain, required time-consuming pain relief interventions and were not always effective. A comprehensive literature search was done to identify alternate repositioning techniques.

Epidemiology

Glenohumeral dislocations commonly present to the ED [1] and are generally due to: sports-related trauma, falls, motor vehicle accidents, and rarely, seizures [2–9]. Minor "trauma" (such as rolling over in bed) can cause dislocations in those with unstable shoulders. The median age range for dislocations in men is 25 to 30 years and 50 to 70 years in women, with an overall male: female ratio of 2.6 to 3.6:1 [2,3,10–14]. Anterior dislocations are most common (93-97%), followed by posterior (1-4%) and inferior (*luxatio erecta*) (0.5-2%) [2,13–16]. Since the 1980s, the incidence of glenohumeral dislocations has increased, from 5.3 to 26 per 100,000 [2,3,10,12,14,15,17].

Anatomy

The glenohumeral joint consists of the small scapular glenoid fossa and a relatively large humeral head. This inherently unstable joint is stabilized by four rotator cuff muscles. In AGDs, the *supraspinatus, infraspinatus* and *teres minor* muscles stretch and spasm, causing pain. It is theorized that spasm of the long head of the *biceps brachii* muscle acts as a "bowstring," keeping the humeral head out of the glenoid fossa. As a result, the AGD patient presents generally with a painful, manually fixed, slightly externally rotated and abducted arm[18].

6

In AGD it is common medical practice to perform reduction quickly, to reduce pain and minimize complications [19]. Successful repositioning occurs when normal glenohumeral anatomy is restored. The patient often experiences this as: decreased discomfort, recovery of function and a feeling that "the shoulder is normal." [20]

Reduction Techniques

More than 50 glenohumeral dislocation repositioning techniques exist. They are described unambiguously in the literature but often inconsistently performed in clinical practice [21,22] . The wide range of techniques can be divided into three groups based on their major mode of action: traction, leverage, or biomechanical [8,18,21–24]. The most commonly used techniques in Dutch EDs are the traction-based Hippocratic method and the leverage-based Kocher method [4].

Traction-based Techniques

Traction-based techniques—such as the Hippocratic method and its variants—rely on force to overcome muscle spasm. The idea being that, by applying traction, muscles will tire, and relocation will occur. The amount of traction the operator can apply can be increased by means of countertraction. Many modifications of the pure Hippocratic method exist, some already suggested by Hippocrates himself, including the application of countertraction with a sheet, the operator's shoulder, the operator's knee, the patient's bodyweight (Eskimo technique), a bed, a chair and a ladder [21–23,25–37]. Since applying traction will increase muscle spasm and pain, traction techniques often require analgesia and/or sedation [22,32,38–41] resulting in prolonged ED lengths of stay [9]. Traction-countertraction techniques may result in neurovascular damage in the axillary region although incidence is unknown [22,23,42].

Leverage-based Techniques

Kocher's method, originally described in 1870, is the best known leverage technique for AGD reduction [43]. The technique has been altered by clinicians since, and often includes traction, which is commonly associated with increased pain [22,29,38,44–46]. This combined technique achieves good results but some force is still needed to manipulate the humeral head over the glenoid [8,24,40,44,47,48]. Additionally, iatrogenically-induced humeral fractures and axillary vessel ruptures are seen with the technique and were, in fact, described by Kocher in his original article [22,29,46,49,50]. Two other studies describe the risk of post-reduction humeral neck fractures during leverage techniques in patients over 40 years of age [51,52].

Biomechanical Techniques

More recently, several techniques with a biomechanical basis have been described. These biomechanical repositioning techniques (BRT) depend on muscular relaxation without force, and often start with the patient's arm in an analgesic position thus eliminating or minimizing the need for sedatives or analgesics. They do require patient cooperation, making it essential that patients receive accurate instruction about the procedure [53]. BRTs can be separated into three approaches: positioning and relaxation, zero position and scapular manipulation.

The Cunningham technique involves positioning and relaxation. The patient's arm must be fully adducted for the technique to succeed. This reduces spasm in the stretched rotator cuff muscles. By massaging the *trapezius,* the *deltoid* and especially the *biceps brachii* muscles, tension in the "bowstringed" *biceps brachii* will decrease and relocation will occur. No traction is applied. [54]

The original Milch technique first described in 1938 and the modified Milch technique described in 1992 involves positioning the patient's arm such that all the muscles acting on the shoulder joint align with the humerus (the so-called "zero position") [44,45,53]. No traction is applied.

The scapular manipulation technique (SMT) was developed in the late 1970s and published in 1982 [55,56]. As the name implies, the SMT involves scapular movement with the patient prone so that the glenoid fossa re-engages the humeral head achieving reduction. In a sense, arm traction is involved as well, but only to stabilize the humeral head, not to fatigue muscles. Patient pain is thereby limited. The classically-described SMT is often modified to a sitting or supine position [23].

Pain Relief

Many methods exist to address the pain associated with AGD, ranging from intra-articular anesthesia to nitrous oxide, nerve blocks and various procedural sedation and analgesia regimens [57–75]. No one method is clearly superior in every regard and all involve time to gather medications, consent the patient, administer (and possibly re-administer) medications, wait for effects, and observe the patient post-procedure as he/she recovers [1,62–68,71–74,76,77]. In addition to these delays and the possibility of inadequate pain relief there is the real risk of complications associated with procedural sedation – nausea and vomiting, hypotension, hypoxemia, prolonged drowsiness, headache, aspiration, respiratory depression and untoward medication reactions, amongst others [58,62,64,65,67,69–74]. Many authors have advocated that the best relief for AGD pain is reduction [8,9,64,73].

Conclusion

A variety of traction- or leverage-based techniques are often successful in repositioning AGDs, with success rates ranging from 60 to 100 percent in generally small studies [22]. However, since pain is increased by traction, countertraction and leverage, these techniques often require the administration of analgesics and sedations which may be associated with complications. Additionally, the techniques themselves may not be quick, painless or complication-free and do not pay heed to patient satisfaction or ED throughput [18]. Consequently, total ED time can be three hours or more for a procedure with a performance time of less than 10 minutes [24,59,63–68,71,72,74,75,78].

In contrast, BRTs do meet the requirements for optimal repositioning [7,9,19,23,53–56,79,80]. "The ideal method should be simple, easy, quick, effective, atraumatic, and pain free; require little assistance or medication; and cause no additional injury to the shoulder joint or to the musculoskeletal or neurovascular structures [8]. "

Data on the BRTs are scarce but the reported minimal inflicted pain, high success rates and the avoidance or reduced need for sedation or analgesia seems promising for a shorter ED stay, lower resource utilization and a better patient experience [9,79]. However, which BRT or BRT combination is fastest, least painful, and least likely to cause complications is unaddressed in the current medical literature.

METHODS AND ANALYSIS

Primary research question:

Which BRT or BRT combination is fastest and least painful for adult ED patients with AGDs?

Secondary research questions:

- Are complications caused by BRTs or BRT combinations? If so, what are those complications?
- What are the reposition success rates of the BRTs or BRT combinations?
- What are the ED lengths of stay associated with the BRTs or BRT combinations?

Study Design

A randomized controlled trial will be conducted in two Dutch hospital-based EDs comparing the three BRTs: modified Milch, Cunningham and SMT [23,53,54].

To optimize technique execution from study outset we will train participating doctors, nurse practitioners and nurses before the study starts. Visual and written instruction will be provided and learning materials will also be available online (see Videos).

Patient recruitment

Adults presenting acutely to the two-study center EDs with isolated AGDs demonstrated on standard shoulder radiographs will be approached about study participation (see Table 1: inclusion/exclusion criteria). Written informed consent—including an opt-out path—will be obtained from all patients. The study commenced August 1st 2016 and will recruit patients for two years.

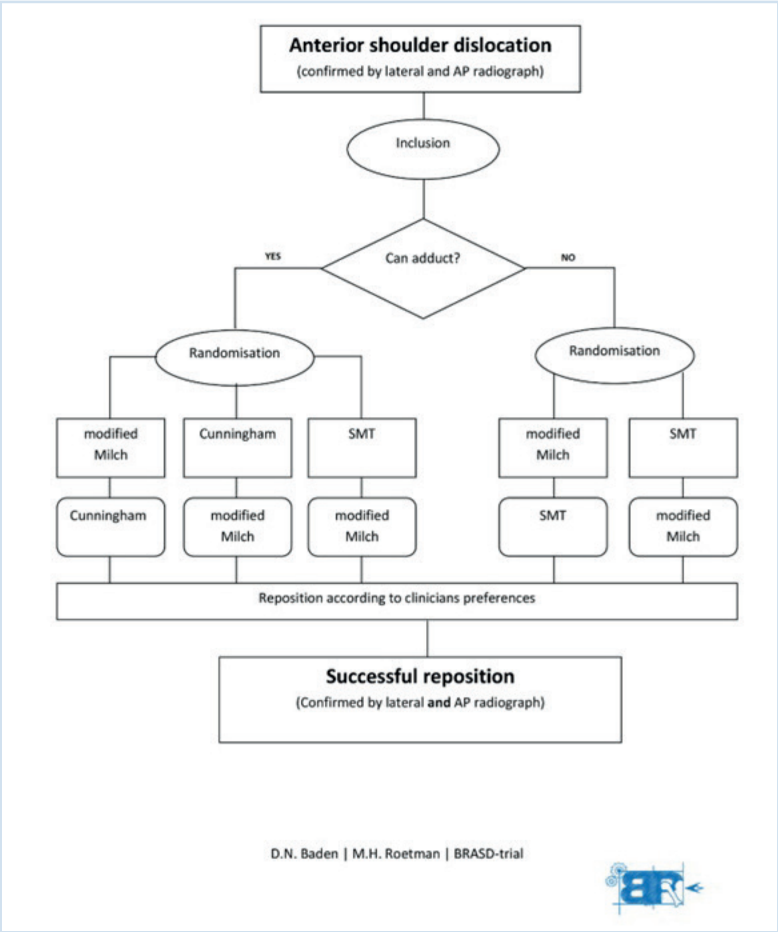
Table 1 inclusion/exclusion criteria

Inclusion: all adult patients (≥18 years) with an isolated AGD less than 24 hours old and able to understand and sign consent.
Exclusion criteria:
A potential subject who meets any of the following criteria will be excluded from participation in this study:
- subcapital humeral fractures
- major multi trauma
- subclavicular, intra-thoracic- , inferior or posterior dislocations
- dislocations presenting after 24 hours.

Investigational Treatment

Patients able to adduct ("can adduct" path) will be randomized to BRT using either: Cunningham, modified Milch or SMT. Those unable to adduct ("cannot adduct" path) will be randomized to BRT using either modified Milch or SMT (see Figure 1 Flowchart).

Figure 1: Flowchart shows the randomization of the BRASD-trial



* Scapular manipulation (SMT)

AGD reduction will be defined as the reestablishment of a normal glenohumeral relationship on post-intervention radiographs. After reduction, an internal rotation sling will be applied, and follow-up arranged in the outpatient clinic.

Data Collection

Baseline demographics, medical history and study-specific data will be collected. ED length-of-stay (LOS) will be defined as the time in minutes from patient arrival in the ED until discharge. The well-validated numeric rating scale (NRS) of 0-10 will be used to assess patients' pain, before, during and after reduction attempts.

Other data to be collected:

- Reduction time (in minutes, from start to end of procedure)
- Number of reduction techniques used
- Sedatives and analgesics used (types, dosages, prehospital and/or in-hospital administration)
- Pre-intervention and post-intervention radiograph interpretation
- Physical examination (with particular attention to neurovascular status of the affected arm)
- Iatrogenic complications (caused by the interventions)
- Patient age
- Patient gender
- Time of last oral intake
- Dislocation number (first or recurrence number)
- Dislocation mechanism (Sports, seizures, falls, traffic accidents, other)

Statistical Methodology

We calculated the sample size on ED LOS per combination of techniques as shown in Figure 1. A 15-minute difference between the combinations of techniques is considered clinically relevant. We assumed a probability of type 1 (alpha) error of 0.05 and a type 2 (beta) error probability of 0.20.

In the "cannot adduct" group, we will compare two combinations of techniques. Assuming non-normality and using the Mann-Whitney test, power calculations lead to a sample size per combination of 31, with a total of 62 inclusions.

In the "can adduct" group we will compare three combinations of techniques. Similar to the calculation of the "cannot adduct" group assuming non-normality and using the Kruskal-Wallis test, power calculations lead to a sample size per combination of 41, with a total of 123 participants required.

One hundred eighty-five inclusions are therefore needed in total. Based on other studies done at one of our hospitals we are anticipating a 20% data loss, so we intend to enroll 222 patients. Enrollment will continue until the required sample size in each arm in reached.

The techniques will be randomized in advance per center by creating a stratified block randomization list.

Nominal variables related to subgroups will be analyzed with the chi-square test. Ordinal variables related to subgroups will be analyzed using the Mann-Whitney U test or the Kruskall-Wallis test. Variables will be compared with each other (depending on the scaling level) with the Wilcoxon test, the Friedman test and the correlation coefficient of Spearman. Nominal and ordinal variables will be described using frequency tables, mode and median. A value of $p < 0.05$ will be accepted as statistically significant.

In cases of missing data, the treating physician will make inquiries. If more than 30% of the data are still missing post-inquiry, the patient will be excluded from the study. SPSS version 22 will be used for data processing.

ETHICS AND DISSEMINATION

This RCT will compare three BRTs described in the medical literature, the modified Milch, Cunningham and the SMT [23,53,54], and will be one of the first comparative studies on BRT outcomes. Its aim is to establish whether different BRTs produce different ED LOS and patient discomfort during and after reduction. This trial will add valuable information to the presently limited knowledge about these techniques. Results of the study will be made publicly available by submitting the results to a peer-reviewed medical journal. No veto or disclosures are made with the sponsors.

AGDs are painful and require timely intervention to relieve and/or minimize discomfort and potential tissue damage. Non-BRTs are based on traction or leverage and therefore inherently painful and potentially harmful. We posit that the BRTs used in our study are more physiological, likely less pain-producing and will lead to a decreased ED LOS while being just as successful as older techniques at repositioning the acute AGD. To date, no adverse events have been described for these techniques. Our study results may help define a more standardized, less risky, improved treatment regimen for AGD patients by minimizing pain and shortening ED throughput times. This may not only benefit individual patients but also healthcare systems.

LIMITATIONS

Since it is impossible to blind physicians and patients to the technique used for shoulder reduction this may introduce a bias toward techniques more favored by some physicians. We are also aware that practitioner learning will occur over the course of the study and individual physicians may gravitate toward or become increasingly adept at certain techniques.

We will attempt to minimize the bias introduced by the absence of blinding, learning effect and optimize technique execution by training the participating doctors, NP and nurses before the study starts. After the study start, we plan to revisit the participating centers to train and answer questions about the techniques used. Also, visual and written instructions will be provided at the start of the study and learning material is also be available on our YouTube channel.

Videos:

1. Cunningham:
https://youtu.be/6TF3h3RNS0M?t=10

2. Modified Milch:
https://youtu.be/yOm1bF-U9Q8

2. Scapular manipulation technique
https://youtu.be/Cig7XRH8cZs

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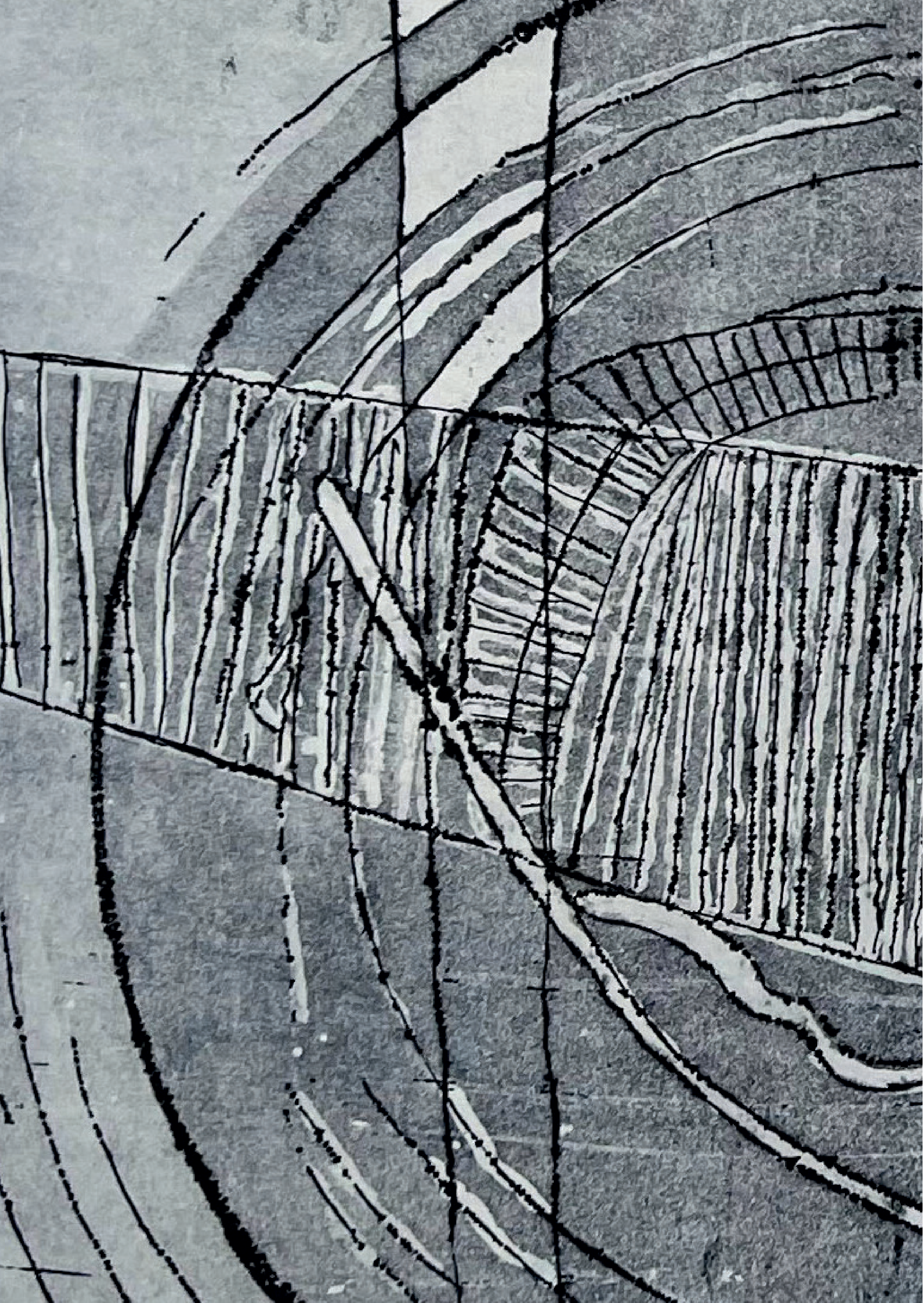

CHAPTER SEVEN

BRASD trial: Biomechanical Reposition techniques in Anterior Shoulder Dislocation - A randomized multicenter clinical trial

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ABSTRACT

Background

Biomechanical reduction techniques for shoulder dislocations have demonstrated high reduction success rates with a limited pain experience for the patient. We postulated that the combination of biomechanical reduction techniques with the fasted length of stay would also have the lowest pain experience and the highest first reduction success rate.

Methods

A randomized clinical trial was performed to compare different biomechanical reduction techniques in treating anterior shoulder dislocations without the use of invasive pain relief. Patients who were able to perform adduction of the arm were randomly assigned to Cunningham, the modified Milch, and the scapular manipulation technique. Those who were not able to do so were randomly assigned to modified Milch and the scapular manipulation technique. Primary outcomes were emergency department length of stay and pain experienced during the reduction process, measured by the numeric pain rating scale. Secondary outcomes were reduction time, reduction success, use of analgesics or sedatives, and complications.

Results

308 Patients were included, of whom 134 in the adduction group. In both groups, no differences in emergency department length of stay and experienced pain were observed between the treatment arms. In the adduction group, the modified Milch technique had the highest first reduction success rates 52% (p=0.016), within protocol 61% (p=0.94) and with sedation in the ED 100% (-). In the no-adduction group the modified Milch was also the most successful primary reduction technique with 51% success (p=0.040)), within protocol 66% (p=0.90) and with sedation in the ED 98% (p=0.93). No complications were recorded in any of the techniques.

Conclusion

A combination of biomechanical techniques resulted in a similar length of stay in the emergency department and showed similar pain scores with an overall high success rate of reduction. In both groups, the modified Milch had the highest first reduction success rate.

BACKGROUND

An anterior shoulder dislocation has a major impact on the patient and places high demands on emergency department (ED) facilities.

The dislocation is often very painful and primary treatment is a timely closed reduction. Pain is caused by muscle spasm in the rotator cuff, which also causes the biceps to contract thus maintaining the dislocation. More than 50 reduction techniques have been described that can be grouped into traction-counter-traction techniques (TCT), leverage techniques, and biomechanical techniques [1,2].

For the patient, as well as for the likelihood of reduction success, an important element is pain relief. Procedural sedation and analgesia (PSA) or intra-articular lidocaine (IAL) techniques require additional personnel, take time setting up and PSA in particular extends emergency department stay considerably. These techniques also carry a risk of complications [3,4]. Another possible method of pain relief is using a reduction technique that has no- or a positive effect on the pain experience

Previous randomized trials concerning shoulder reduction techniques, without the use of PSA or IAL, showed mixed results in success rate and pain relief [5,6]. In traction-counter traction and leverage techniques complications are described and the application of more force seems to increase the risk of complications [7,8].

In previous studies on shoulder dislocation, the primary outcome parameter was reduction success. Although initial success rates vary across studies, eventually almost all techniques appear to have a success rate of 80-90% [7,9,10]. Therefore, we considered emergency department length of stay (LOS) an alternative primary outcome measure which arguably better reflects the burden and safety for the patient, impact for the emergency room and offers a different view point.

The Cunningham technique (CH), modified Milch (MM), and scapular manipulation technique (SMT) are among the most frequently used biomechanical reduction techniques [11]. In contrast to traction-counter traction and leverage techniques, biomechanical techniques are primarily performed without invasive pain relief like PSA or IAL [5,6,12,13]. To date, however, there are no studies directly comparing these three biomechanical techniques.

Therefore, the aim of this study was to compare these different biomechanical reduction techniques without the use of invasive pain relief regarding to emergency department length of stay (LOS) and experienced pain. We Hypothesized that the combination technique with reduced LOS would also have the lowest pain experience and the highest first reduction success rate.

METHODS

For a detailed description of the design of this study, we refer to the study protocol [1]. During the study, no changes were made to the study protocol. Approval for this study was obtained from the local ethics committee (CCMO-number NL54173.094.15) and registered in the Netherlands Trial Register (NTR5839). The Consort guidelines were followed.

Inclusion

From August 1st, 2016 to December 31st, 2018, all patients who presented with an anterior shoulder dislocation at the emergency departments of four regional hospitals across the Netherlands were screened for enrolment. All involved hospitals are level 2 trauma centers with an annual ED-volume of approximately 30.000 patients.

Eligible patients, with an anterior shoulder dislocation confirmed by radiograph were included by the treating clinicians when aged ≥18 years old. In patients who suffered recurrent shoulder dislocations, minimal trauma (i.e. no fall or body to body contact) and a strong clinical suspicion of a dislocation, the radiograph could be omitted. Patients were excluded if they suffered from multi-trauma, if the dislocation coincided with a fracture of the proximal humerus or presence of the dislocation of more than 24 hours. The latter due to the possible increased risk of treatment failure as previously described and for comparison purposes with existing literature [5,6,14]. Written informed consent was obtained from all participants.

Randomization and treatment allocation

Participants were classified by the treating physician based on the ability to perform adduction (active or passive) of the injured arm by touching the torso with the elbow. Adduction is an important part of the Cunningham technique; without adduction this technique cannot be performed.

Within each of the groups ('adduction' versus 'no adduction'), patients were then randomized with equal probability to the different treatment arms using a computer-generated block randomization, stratified by center, with a block size of 10. When a patient with a possible anterior shoulder dislocation entered the emergency department, the treating physician was given two blinded envelopes containing the randomized techniques. A green envelop was opened if adduction could be performed and a red envelop was opened if adduction could not be performed. The unused envelop was returned. The envelops were numbered for each individual hospital in order to maintain randomization order. Patients and doctors could not be blinded to the individual techniques as this was technically impossible.

In the 'adduction' group, patients were randomized to one of three techniques: the Cunningham (CH), the modified Milch (MM), and the scapular manipulation technique (SMT). See Figure 1 and the videos for a description of the techniques. There was a crossover to a pre-determined second technique after the attempt with the first allocated technique failed, if both techniques were unsuccessful the subsequent (third) technique used was left to the discretion of the treating physician. In the 'no-adduction' group, patients were randomized to two techniques: the MM and the SMT. Criteria for crossover were the same. It was advised in the pre-trial training to try the Cunningham and the scapular manipulation technique for at least 10 minutes. If necessary the operator could perform a repositioning of the arm during the modified Milch technique.

Figure 1: Description of reduction techniques: The pictures were taken at the emergency department of the Diakonessenhuis by the authors from a volunteer.

Scapular manipulation

How to perform

Seated scapular manipulation allows the patient to remain seated upright. Facing the patient, a physician or assistant grasps the wrist of the patient affected side and slowly raises this to the horizontal plane and let the palm of the hand face upwards (exorotation) (figure 1a). Firm, but gentle, forward traction is applied with counterbalancing provided by placing the palm of the extended free arm over the patient's midclavicular region. The force required in applying this traction is not great. Once gentle traction is applied, a second physician or assistant manipulates the scapula by applying constant pressure on the abducted inferior tip of the scapula to medial, while holding the upper part of the scapula and put pressure on this to lateral. This allows the abducted inferior tip of the scapula to be rotated bringing the scapular neck and glenoid fossa into correct alignment (figure 1b)

It sometimes takes some time (minutes) before the muscles relax and the scapula moves. The shoulder is reduced when the scapula moves and the assistant feels the humeral head moving back in anatomical position. [17]

Image 1a

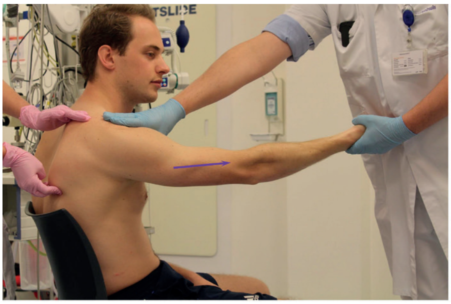


Image 1b

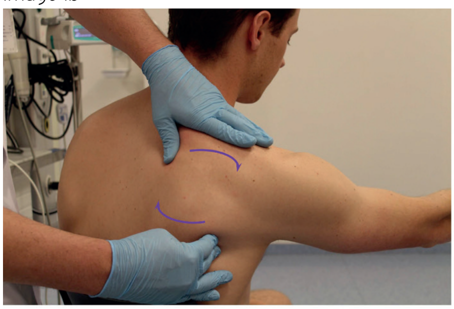


Figure 1: Continued

Modified Milch

How to perform

Dislocated shoulder of the seated patient is positioned in an analgesic position by externally rotating the extended arm and slightly abduct anterolateral. This will decrease tension on m. infraspinatus, m. terres minor and m. supraspinatus (figure 1c). Gently abduct the exorotated arm until reduction is achieved, often around 140-160 degrees (figure 1d). Placing a thumb in the armpit can prevent the humeral head from sliding medially. No traction is used, but the arm is kept on length by the physician. After completing the 180 degrees abduction the arm is moved back in front of the patient to a neutral position. The procedure is painless, but sometimes gives discomfort when the humeral head is moving back in place. If there is pain while abducting the arm the speed of movement should be slowed down and/or a more anterior or posterior trajectory of the abduction can be followed [9,18].

Image 1c

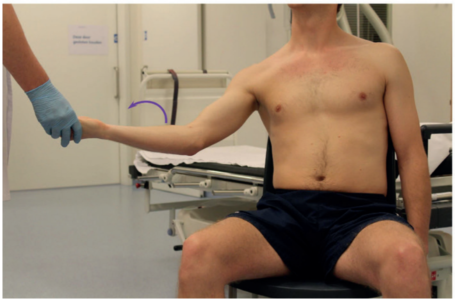


Image 1d

Figure 1: Continued

Cunningham

How to perform

The patient sits upright against a hard surface (ie chair of upright bed), the affected arm adducted to the body and the elbow fully flexed. The operator kneels/sits next to the patient and places his wrist onto the patient's forearm (no pressure, this adds discomfort to the patient), the patient's hand resting on the operator's shoulder (figure 1e). It is important to keep the injured arm close to the body of the patient and flex their elbow to relax the bicep muscle. The patient is asked to shrug the shoulders superiorly and posteriorly, which 'squares off' the angle of the shoulder (reducing scapular anteversion and the static obstruction of the glenoid rim). Start with the trapezius and deltoid muscles and afterwards move to the bicep muscle (figure 1f). Then biceps is massaged at mid-humeral level to specifically relax the muscle (removing dynamic obstruction).

The massage is not to relax the muscles by the physician, but to make the patient conscious of their muscle tension. Reduction is often after a couples of minutes and is expected when the shoulder contour has been restored. [9]

Image 1e

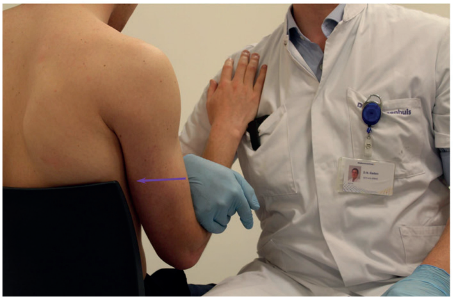
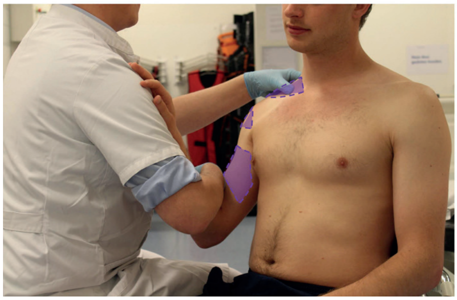


Image 1e



To compare the techniques as reliably as possible, the study protocol explicitly advised against the use of pain medication during the process of shoulder reduction. Any medication given before arrival in the emergency department or during triage was recorded. If the study protocol was not successful and a third technique was used, the treating physician could use medication to his or her discretion, this was also recorded. After shoulder reduction, all patients received a radiograph to confirm reduction and the shoulder was immobilized in internal rotation with a sling. Regular follow-up in the outpatient clinic was scheduled in accordance with regular care.

Training

All involved medical staff underwent training from the two lead investigators of the reduction techniques prior to the study, theoretical as well as a hands-on training. Additional information was also provided in the form of a pocket card and the URL of our Youtube channel (see link under videos). In all four participating centers one of the investigators was available for questions if requested about the techniques and the study-protocol.

Patient and Public Involvement

In our work in the ED we asked patients during their ED-visit about their key points of attention in both the reduction as the process of the ED-visit. We have based our research questions on those stories.. Because most patients have had a shoulder dislocation only once or a limited number of times we found it difficult to engage them in research. And we did not involve patients or the public in the development of the protocol or analysis of the results.

Primary outcomes

The primary outcomes were length of stay at the emergency department, defined as the time between the moment of arrival at the emergency department until the patient was discharged, and the maximum levels of pain experienced by the patient during the reduction. Pain was measured using the numeric rating scale (NRS), which ranges from 0-10.

Secondary outcomes

The secondary outcomes were the time needed for reduction in minutes from start until end of reduction, the reduction success, effect of habitual dislocation on reduction success, the number of techniques used for reduction, use of analgesia or sedatives administered in the ED, and possible complications of the reduction (bony or neurovascular).

Data collection

The physician responsible for study inclusion prospectively recorded pain scores, reduction time, reduction success, age, sex, dislocation side, dislocation time, previous dislocations, history, injury mechanism, any complications, reduction time and neurovascular examination before and after reduction. In addition, the time required for actual reduction was recorded using a clock present in the treatment room, different timepoints of the ED stay (arrival, radiograph, reduction start, end and departure from the ED) and NRS were also noted during the reduction by the treating medical staff present at the reduction (see supplemental file 1 for all recorded parameters). All pre- and post-reduction radiographs were reviewed by the treating physician, the radiologist on call and afterwards (blinded for the result of physician and radiologist) by the two main investigators (DB and MR) to assess for fractures.

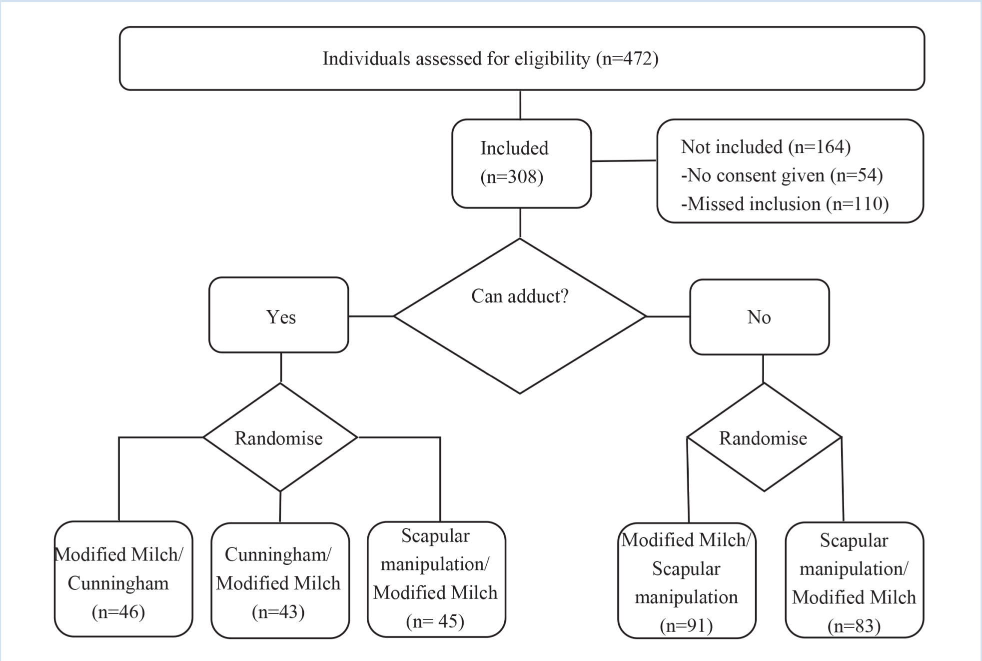
Statistical analysis

Sample size was calculated based on a clinically relevant difference in length of stay at the emergency department of 15 minutes between different techniques. The probability of a type 1 error (alpha) was set at 0.05 and with a power of 0.80; this led to a required total sample size of at least 62 in the no-adduction group and 123 in the 'adduction' group, based on an assumed standard deviation of 20 minutes in both groups. Analyses were conducted according to the intention-to-treat principle. Continuous outcomes were compared using ANOVA (no-adduction group) or t-test (adduction group) and binary outcomes using the chi-squared test. Only observed outcomes were included for analysis. A p value <0.05 was considered statistically significant. All analyses were conducted using SPSS version 21 [15].

RESULTS

Out of 472 eligible patients, 308 patients were included in the study. Of the 164 patients not included, 54 did not provide consent and 110 were excluded as the treating physician did not ask for consent. All randomized patients were included in the analyses (see Figure 2). The shoulder reductions were carried out by 110 different professionals with varying experiences with the techniques. Of the included patients, 31% were treated by an emergency physician, 66% by an emergency medicine resident, and 3% by a nurse practitioner. These percentages were similar across the different treatment arms (see Supplementary Table I and Supplementary Table 2).

Figure 2: Randomization en inclusion schedule



Adduction group

Baseline characteristics of the 134 patients included in the adduction group are presented in Table 1. Their mean age was 50 years (SD 22), 50 patients were female (37%) and the most frequent cause of the shoulder dislocation was a fall (n=67 cases, 50%). (see table 1)

Table 1: Characteristic of patients with anterior shoulder dislocation in the 'Adduction group' of the BRASD-trial

Variable	Modified Milch/ Cunningham	Cunningham/ Modified Milch	SMT/Modified Milch
Number of patients	46	43	45
Mean age (SD)	48 (21)	51 (21)	51 (24)
Mean age men (SD)	38.9 (19.0)	42.8 (20.7)	43.3 (20.8)
Mean age women (SD)	64.3 (16.1)	64.4 (14.7)	63.2 (24.3)
Gender			
Men (%)	30 (65)	26 (60)	28 (62)
Female (%)	16 (35)	17 (40)	17 (38)
Dominant arm	N=44	N=43	N=43
Right (%)	38 (83)	39 (90)	38 (84)
Left (%)	6 (17)	4 (10)	5 (16)
Dislocation in dominant arm	N=44	N=43	N=43
No (%)	16 (35)	20 (47)	20 (44)
Yes (%)	28 (65)	23 (53)	23 (56)
Trauma mechanism			
Sport	20	6	10
Seizure	1	2	3
Fall	16	27	24
Traffic accident	-	-	-
Other cause	9	8	8
NRS at arrival (SD)	7.4 (1.8)	7.3 (2.3)	7.2 (2.0)
Type of practitioner			
ED-physician	9	17	18
Resident	35	26	26
Nurse Practitioner	2	0	1
Medication used			
No	10	12	9
Oral medication	25	19	25
Intra-articular	0	0	0
IV medication	20	25	22
Fracture (pre-reduction)*	N=38	N=38	N=43
No	29	25	25
Greater Tuberosity	1	2	1
Bony Bankart lesion	4	8	9
Hill Sachs lesion	4	3	8
First-time dislocations (%)	28 (61)	30 (70)	29 (64)

* Numbers are different because of missing X-ray

Primary outcomes

The mean LOS at the emergency department for the 'adduction' group was 120 min (SD 68 min). The mean total LOS at the ED was similar across treatment arms: in the MM/CH arm 110 min (SD 61 min), the CH/MM arm 125 min (SD 75 min) and the SMT/MM arm it was 126 min (SD 69 min); p=0.45.

There was no difference between the treatment arms regarding the maximum level of pain experienced by patients during reduction with the first technique (Table 2). The mean maximum level of pain experienced was 5.6 (SD 2.8) in the MM arm, 5.0 (SD 2.9) in the CH arm, and 6.1 (SD 2.8) in the SMT arm (p=0.21 for comparison between treatment arms).

Table 2: Outcomes of patients with anterior shoulder dislocation in the 'Adduction group' of the BRASD-trial

	Modified Milch/ Cunningham n=46	**Cunningham/ Modified Milch n=43**	**SMT/ Modified Milch n=45**	**p-value**
Primary outcomes				
Time total length of stay (minutes, SD)	110 (61)	125 (75)	126 (69)	0.45
NRS first technique during reduction	5.6 (2.8)	5.0 (2.9)	6.1 (2.8)	0.21
Maximum NRS during reduction within protocol (SD)	5.7 (2.9)	5.8 (3.0)	6.4 (2.5)	0.41
Secondary outcome				
Time reduction first technique successful (minutes, SD)	8 (11)	3 (2)	3 (3)	0.14
Time start reduction until end reduction; all reductions (minutes, SD)	20 (27)	29 (50)	21 (26)	0.43
Reduction success with first technique	24 (52%)	10 (23%)	15 (33%)	0.016
Reduction success within protocol (%)	28 (61%)	27 (63%%)	29 (64%)	0.94
Reduction success without sedation in the ED	43 (94%)	38 (88%)	38 (84%)	0.39
Reduction success in the ED	46 (100%)	43 (100%)	45 (100%)	-
Reduction success first technique with first-time dislocation	14 (50%)	6 (20%)	10 (35%)	0.024
Reduction success first technique with recurrent dislocation	10 (55%)	4 (31%)	5 (31%)	0.36

Secondary outcomes

Overall, the mean time from start of the reduction until the end of reduction was 23 minutes (SD 35), without differences between the treatment arms. (Table 2).

The overall success of reduction within the protocol (the two techniques combined) was 63%, with no relevant difference in the treatment arms. There is a relevant difference between treatment arms in first technique success: MM was successful in the first attempt in 52% of patients, while for CH and SMT, this was 23% and 33%, respectively (p= 0.016). Ultimately, with the use of PSA, all patients could be treated in the emergency department and no patient required neuromuscular blocking agents or general anesthesia for the reduction. No complications were documented for any of the reduction techniques.

No-adduction group

Baseline characteristics of the 174 patients included in the 'no-adduction' group are presented in Table 2. Their average age was 43 years (SD 19), 41 patients were women (24%) and the most frequent cause was a fall (n=78 cases, 45%). (see table 3)

Primary outcome

The mean total LOS at the emergency department for the 'no-adduction' group was 109 min (SD 65 min), in the MM/SMT arm 114 min (SD 60 min) and in the SMT/MM arm 104 min (SD 64 min); p=0.30.

There was no difference between the treatment arms in this group regarding the maximum level of pain experienced by patients during reduction with the first technique (Table 4). The mean maximum level of pain experienced was 6.4 (SD 2.8) in the MM treatment arm and 6.3 (SD 2.9) in the SMT treatment arm (p=0.91 for comparison between treatment arms)

Table 3: Characteristic of patients with anterior shoulder dislocation in the 'No-adduction group' of the BRASD-trial

Variable	Modified Milch/SMT	SMT/Modified Milch
Number of patients	91	83
Mean age (SD)	44 (20)	42 (19)
Mean age men (SD)	38.5 (16.6)	37.7 (16.5)
Mean age women (SD)	61.8 (19.9)	54.6 (19.4)
Gender		
Men (%)	69 (76)	64 (77)
Female (%)	22 (24)	19 (23)
Dominant arm	N=90	N=80
Right (%)	78 (86)	74 (89)
Left (%)	12 (14)	6 (11)
Dislocation in dominant arm	N=90	N=80
No (%)	40 (44)	37 (46)
Yes (%)	50 (56)	43 (54)
Trauma mechanism		
Sport	23	27
Seizure	2	2
Fall	42	36
Traffic	4	1
Others	20	17
NRS at arrival (SD)	7.2 (2.6)	7.5 (2.0)
Type of practitioner	N=90	N=83
ED-physician	32	19
Resident	55	61
Nurse Practitioner	3	3
Medication used		
No	19	17
Oral medication	50	41
Intra-articular	1	1
IV medication	42	49
Fracture (pre-reduction)*	N=76	N=74
No	50	49
Greater Tuberosity	6	6
Bony Bankart lesion	8	11
Hill Sachs lesion	12	8
First-time dislocations (%)	53 (58%)	35 (42%)

* Numbers are different because of missing X-ray

7

Table 4: Outcomes of patients with anterior shoulder dislocation in the 'No-adduction group' of the BRASD-trial

	Modified Milch/ SMT n=91	SMT/ Modified Milch n=83	P-value
Primary outcome			
Time total length of stay (minutes, SD)	114 (60)	104 (64)	0.30
NRS first technique during reduction (SD)	6.1(2.9)	N=82 5.9 (2.8)	0.68
Maximum NRS during reduction within protocol (SD)	N=90 6.4 (2.8)	N=82 6.3 (2.9)	0.91
Secondary outcome			
Time reduction first technique successful (minutes, SD)	5 (4)	3 (3)	0.003
Time start reduction until end reduction; all reductions (minutes, SD)	25 (39)	17 (21)	0.93
Reduction success with first technique	47 (51%)	30 (36%)	0.040
Reduction success within protocol	60(66%)	54 (65%)	0.90
Reduction success without sedation in the ED	75 (82%)	71 (86%)	0.58
Reduction success in the ED	89 (98%)	81 (98%)	0.93
Reduction success first technique with first-time dislocation	27 (51%)	14 (30%)	0.032
Reduction success first technique with recurrent dislocation	20 (53%)	16 (46%)	0.56
Success first technique in age groups:			
18-45	34 (65%)	23 (43%)	0.024
46-older	13 (33%)	7 (23%)	0.36 p-value for interaction: 0.55

Secondary outcome

Overall, the mean time from start of the reduction until the end of reduction was 20 minutes (SD 15 min). Difference between the treatment arms was not significant: in the MM/SMT arm 25 min (SD 39 min and in the SMT/MM arm 17 min (SD 21 min; p=0.93).

The overall success of reduction within the protocol (both techniques combined) was 66%, with no relevant difference in the treatment arms. Relevant differences were observed between treatment arms regarding the success rate of the first reduction technique: MM was successful in 51% of patients and SMT in 36% of patients (p=0.040).

This reduction success rates increased to 98% by use of PSA in the ED. In both study arms two patients required general anesthesia and muscular blocking agents in the operating room for reduction. No complications were recorded in any of the techniques.

DISCUSSION

In this randomized trial, no differences were found regarding length of stay in the emergency department during the reduction process, regardless of the applied shoulder biomechanical reduction technique or possibility to adduct the arm. Also, neither in the adduction nor in the no-adduction group differences were observed concerning the maximum pain endured during the reduction. With regard to the reduction time, no differences were observed in the 'adduction' group, yet a difference was observed in favor of the Scapular Manipulation Technique among patients who could not perform adduction of the injured arm.

In both groups, a larger initial success rate was observed in the Modified Milch treatment arm compared to the other reduction techniques. Ultimately, the success rate in the ED of both groups is very high, 100% and 98% for the 'adduction' and 'no-adduction' groups respectively.

The total LOS in the ED does not seem to be influenced by the technique used. This is probably because LOS is influenced by multiple factors such as time to triage, the treating physician and staff, waiting time for the pre- and post-reduction radiograph and time until discharge [16]. The LOS is also influenced by the success rate of the first technique. No prior studies are available for comparison.

Pain experienced during the reduction process was lower in both groups compared to pain at the time of emergency department arrival. This is in line with another study on biomechanical reduction techniques [6]. The maximum pain during the first reduction attempt corresponds with Amar et al., but are higher than in 2 other studies [5,6,12]. The reason could be the timing of measurement of the pain scores. Amar et al. analyzed pain scores at several moments in time too, yet the two other studies only determined the pain score during the actual reduction, possibly making it more difficult for the patient to indicate the changes in the experienced pain.

The reported reduction time of a successful reduction using the first allocated technique is similar to what is reported in the literature on biomechanical techniques varying from 130-281 seconds [5,6,12,13]. Total LOS does not seem to vary between the arms in our study. We think that the total time needed for reduction in our study is influenced more by providers switching back and forth between different maneuvers, than by the techniques used. Factors for this extra time can be that additional assistance might be required, or the patient requires additional explanation. Also, the need for PSA can increase the time needed for the reduction time [16].

Studies with biomechanical techniques showed a first technique success between 69%-89% [5,6,12,13]. To our knowledge, there are no previous trials directly comparing SMT or Cunningham which makes it harder to compare the first technique success rate. In the present study we observed lower first reduction success rates compared to previous studies assessing the modified Milch technique [13]. This might be influenced by the wide range of experience of the treating clinicians in this study. Another explanation might be that we advised treating clinicians to take a minimum of 10 minutes per technique, to ensure the required adequate muscle relaxation. Perhaps this time frame was too short since eventually there was an almost 100% reduction success without the use of IAL or PSA.

Our results demonstrated that the modified Milch technique had the highest first technique success rate in both groups. This could be due to the fact that the technique is easy to learn, with few pitfalls in execution. Perhaps the effect of the technique is enhanced by the patients' awareness of the actual reduction process. Both in SMT and Cunningham we considered that the mechanism of relaxation is less obvious to the patient and so they have less positive feedback on the relaxation of the muscles. Also, the SMT is less desirable because it requires two people to perform.

The maximum pain during the first reduction attempt seems to be the in line with other studies, these studies seem to have a higher NRS if multiple pains scores are done in contrast with only one during the reduction [5,12,13]. We found comparable pain scores with the study doing multiple pain scores. This might be of importance when analyzing patients' pain experience in future studies.

This study has several strengths; it is a randomized multicenter trial, equally distributed across the participating centers. In addition, it is applicable to the average day-to-day emergency department setting. A large group of medical staff was involved, often with little experience, and the study included a heterogeneous population of patients. Attention was also directed to (limiting) medication use, which we think is a confounder in reduction studies. In a recently performed survey we showed that ED providers use traction techniques and biomechanical techniques almost as often as their first technique, this study could warrant the use of biomechanical techniques even further [11].

This study also has limitations. First, patients may have wrongfully entered the no-adduction group, for example due to inexperience of medical staff who had to classify participants. Proper judgement of the ability to adduct the arm in a painful situation of a shoulder dislocation requires experience. Second, despite the training of the medical staff, it is possible that there has been variation in the implementation of the techniques. Third, due to the large number of treating clinicians, including residents, and the relatively small number of reductions per physician there could have been knowledge decay of the techniques. Fourth, traction-counter traction or leverage techniques were not included in our study for comparison as, but in our experience, patients require sedation for proper reduction with these techniques. Fifth, the power calculation of our primary outcome LOS was based on the assumption that the standard deviation (SD) of LOS would be approximately 20 minutes, while this turned out to be 75 min. The larger SD makes our study (in hindsight) underpowered to detect a difference in LOS of 15 minutes between the techniques. Finally, after review of the sealed envelopes at the end of the study there were six envelops missing in total, four in the adduction and two in the no-adduction group. This is less than 2% of the total inclusions and, therefore, we do not think this has substantially influenced the outcome of the study.

Ultimately, one might conclude that LOS is not the ideal primary outcome measure to analyze the reduction success. The influence of the other factors turned out to be much greater than the actual reduction time. In future research, reduction success is the better choice as primary endpoint .

Future research should focus on several areas: (1) the influence of muscle tension and muscle group relaxation on successful reduction, (2) the effect of learning curve of the biomechanical techniques on reduction time and success, and (3) it would be interesting to see if there are techniques that have a faster turnaround time and higher success rate in older patients.

CONCLUSION

This is the first randomized study to compare multiple biomechanical shoulder reduction techniques with regards to patient length of stay in the emergency department and pain experience, minimizing and recording the impact of confounders, especially medication use. The different techniques did not appear to influence the total length of stay in the emergency department or the reduction time. There was also no difference in perceived pain. This study demonstrates that a near 100% reduction success in the ED is possible when using a combination of biomechanical shoulder reduction techniques, encouraging every ED physician to acquire these techniques. We recommend starting a reduction with the modified Milch technique.

Videos:

1. Cunningham:
https://youtu.be/6TF3h3RNS0M

2. Modified Milch:
https://youtu.be/yOm1bF-U9Q8

3. Scapular manipulation technique
https://youtu.be/Cig7XRH8cZs

4. YouTube channel BRASD-trial playlist
https://www.youtube.com/playlist?list=PLE9SsnaLVuUIHFDxaos05Hgsb0cJ3Yt0P

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7

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SUPPLEMENTAL MATERIAL

Supplement 1: Recorded data

Age
Sex
Function treating physician (Emergency physicians, emergency resident, nurse practitioner)
Treatment date
Arrival time in the ED
Dislocation side
Means of arrival
Date and time of dislocation
Trauma mechanism
Number of previous dislocations
Number of reduction attempts before hospital arrival
Dominant arm
NRS at arrival
Last meal
Medication before hospital arrival or in triage
Fracture on X-ray before reduction
Position of humeral head before reduction
1st Reduction start time
1st Reduction end time
NRS before 1st reduction
NRS during 1st reduction
NRS after 1st reduction
2nd Reduction start time of applicable
2nd Reduction end time of applicable
NRS before 2nd reduction
NRS during 2nd reduction
NRS after 2nd reduction
3th Reduction start time of applicable
3th Reduction end time of applicable
Medication used during reduction
Sedation
Reduction in the operating room
Neurovascular status before reduction
Neurovascular status after reduction
Time of x-ray before reduction
Time of x-ray after reduction
New fracture on X-ray after reduction
Discharge time of ED

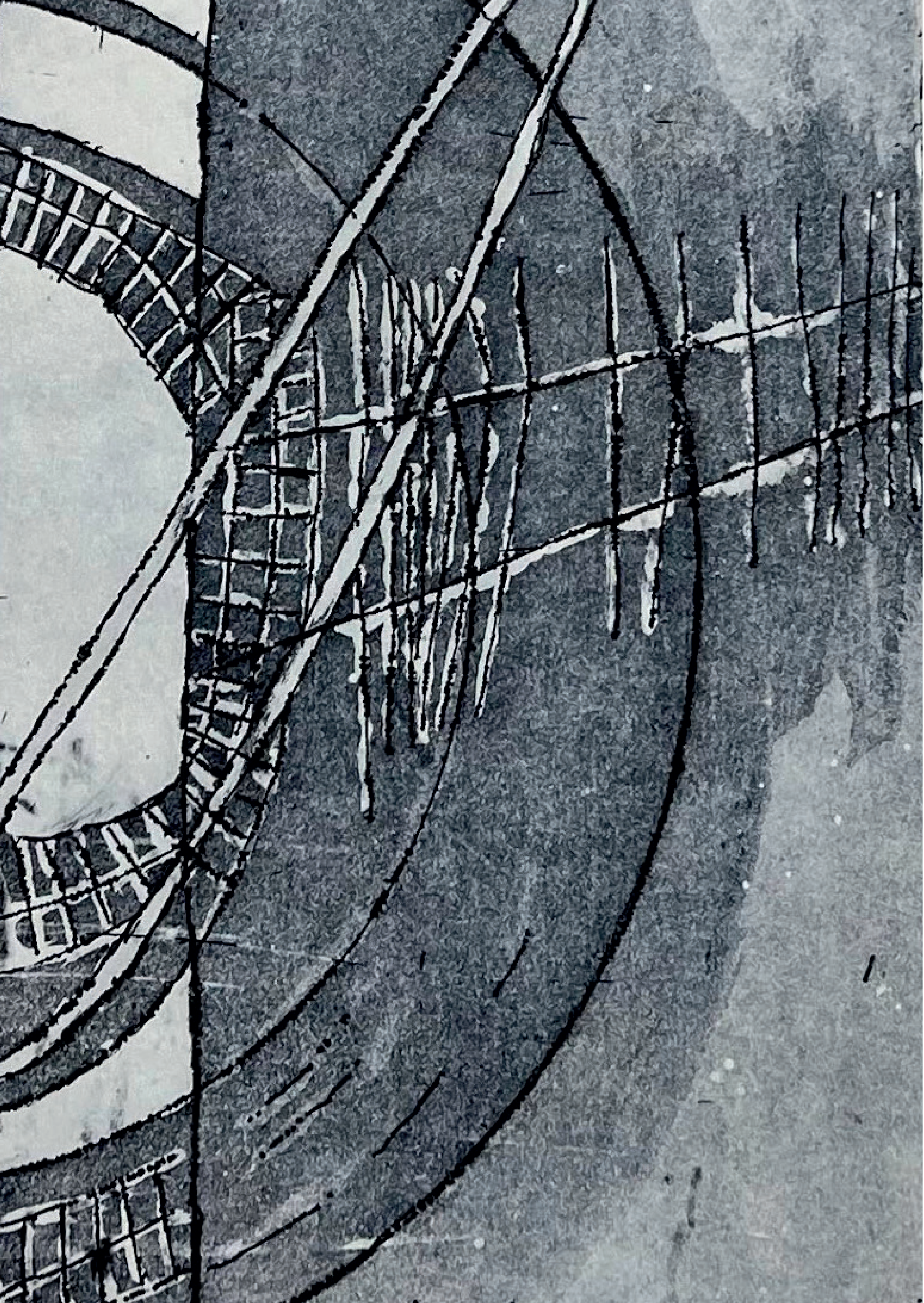
Supplementary Table 1: Supplement group characteristics and results – 'Adduction group'

	Modified Milch/ Cunningham	Cunningham/ Modified Milch	SMT/ Modified Milch	P-value
Number of patients	46	43	45	
Characteristics				
Function treating professional:				
Emergency physician	9	17	18	
Resident	35	26	26	0.14
Nurse practitioner	2	0	1	
Pre-enrolment medication use:				
No	10	12	9	0.85
Oral medication	25	19	25	0.51
Intra-articular	0	0	0	-
IV Opioids/Benzodiazepines	20	25	22	0.38
Medication use during reduction:				
No	37	30	35	0.47
Oral medication	1	1	1	1.0
Intra-articular	2	8	3	0.05
IV Opioids	7	10	6	0.43
Pre-reduction fractures:	N=38	N=38	N=43	
None	29	25	25	
Tuberculum majus	1	2	1	0.51
Bankart	4	8	9	
Hill Sachs	4	3	8	
Results				
NRS first technique pre-reduction	6.37 (2.1)	6.3 (2.5)	6.47 (2.32)	0.94
NRS first technique during reduction	5.57 (2.8)	5.0 (2.9)	6.07 (2.8)	0.21
NRS first technique post-reduction	4.09 (3.2)	4.63 (2.9)	N=44 4.8 (2.98)	0.51
Number of techniques used:				
1	10 (55%)	4 (31%)	5 (31%)	
2	3 (17%)	6 (46%)	7 (44%)	0.36
3+	5 (28%)	3 (23%)	4 (25%)	
Number of techniques used non-habitual				
1	14 (50%)	6 (20%)	10 (35%)	
2	1 (4%)	11 (37%)	7 (24%)	0.024
3+	13 (47%)	13 (43%)	12 (41%)	
Number of techniques used habitual				
1				
2	10 (55%)	4 (31%)	5 (31%)	
3+	3 (17%)	6 (46%)	7 (44%)	0.36
	5 (28%)	3 (23%)	4 (25%)	
Type of third techniques used:				
Traction	12 (26%)	8 (19%)	10 (22%)	
Leverage	3 (7%)	5 (12%)	3 (7%)	0.85
Biomechanical	3 (7%)	3 (7%)	3 (7%)	

Supplementary Table 2: Supplement group characteristics and results – 'No-Adduction group'

Variable	Modified Milch/ SMT	SMT/ Modified Milch	P-value
Number of patients	90	83	
Characteristics			
Function treating professional:			
Emergency physician	32	19	
Resident	55	61	
Nurse practitioner	3	3	0.19
Pre-enrolment medication use:			
No	19	17	0.95
Oral medication	50	41	0.46
Intra-articular	1	1	0.95
IV Opioids/Benzodiazepines	42	49	0.09
Medication use during reduction:			
No	74	71	0.46
Oral medication	1	0	0.34
Intra-articular	7	4	0.44
IV Opioids	11	9	0.80
Pre-reduction fractures:	N=76	N=74	
None	50	49	
Tuberculum majus	6	6	0,74
Bankart	8	11	
Hill Sachs	12	8	
Results			
NRS first technique pre-reduction (SD)	6.72 (2.51)	6.69 (2.52)	0.78
NRS first technique during reduction (SD)	6.09(2.91)	N=82 5.89 (2.82)	0.68
NRS first technique post-reduction (SD)	4.40 (3.31)	N=80 4.89 (3.19)	0.52
Number of techniques used:			
1	47 (51%)	30 (36%)	
2	13 (14%)	24 (29%)	0.034
3+	31 (34%)	29 (35%)	
Number of techniques used non-habitual			
1	27 (51%)	14 (30%)	
2	9 (17%)	12 (25%)	0.10
3+	17 (32%)	21 (45%)	
Number of techniques used habitual			
1	20 (53%)	16 (46%)	
2	4 (10%)	12 (34%)	0.036
3+	14 (37%)	7 (20%)	
Type of third techniques used:			
Traction	15 (17%)	16 (19%)	
Leverage	5 (6%)	3 (4%)	0.77
Biomechanical	10 (11%)	9 (11%)	

7



CHAPTER EIGHT

Summary, Discussion, Perspective

SUMMARY

Although shoulder reduction techniques have been used for over 3,000 years, no "best treatment" consensus exists. This is especially true regarding pain management and reduction technique choice. The studies outlined in this thesis, and their discussions, have attempted to provide clarity on these issues. This chapter will further discuss study findings and their implications for medical practice. Future research directions will be discussed as well.

Chapter two provides a general description of current shoulder dislocation management. The influence of acute shoulder dislocation treatment on subsequent functional outcome is reviewed as well. Shoulder dislocations are painful and potentially damaging to bones, muscles, tendons, ligaments, nerves and vasculature. They often have long-lasting impact on daily activities and on the ability to participate in sports. Treatment beyond the acute phase focuses on preventing subsequent dislocations and returning the patient to normal function, if possible, thereby minimizing societal cost by maintaining patient functionality. Patients with a first time dislocation often receive limited and inadequate information on long-term treatment options like surgical repair and non-surgical physical rehabilitation. Shared decision-making is important as treatment should fit individual expectations and needs.

To provide insights on current treatment strategies for patients with anterior shoulder dislocations presenting to Dutch Emergency Departments (ED), **chapter three** reports the results of a survey of emergency physicians in The Netherlands. The survey focused on (administration of) pain relief, reduction technique of choice, and possible complications. It was distributed to members of the Dutch Society of Emergency Physicians (NVSHA). Results indicated that 44% of respondents used a traction method first. Biomechanical techniques were used by 40% of respondents in their initial reduction attempts. Only 12% favored a lever technique as their first approach, and 4% of the techniques could not be classified. Complications were inconsistently reported, making analysis impossible. A wide range of pain medications were used. Most commonly, an intravenous opiate was employed. The anesthetic agent, Propofol, was the most used sedative. Most respondents reported a first-attempt success rate of 75% or higher, regardless of reduction technique used. Overall, the survey indicated that a wide variety of shoulder reduction management strategies—in technique and pain relief—are currently employed in Dutch EDs.

ED overcrowding is a significant issue in The Netherlands, making ED length-of-stay (LOS) increasingly important. **Chapter four** outlines a retrospective study, conducted in two Dutch hospitals, detailing the factors influencing ED-LOS for patients with a dislocated shoulder. Data were collected from 2010 to 2016 on patients over the age of 12 presenting with a dislocated shoulder. Electronic health records were abstracted for: trauma mechanism, reduction method(s), medication used to treat pain and facilitate reduction, complications, and ED-LOS. During the study period, 716 anterior shoulder dislocations (ASD) were seen in 574 patients, of which 374 (65.2%) were male. First-time ASDs numbered 389 (54.3%). Median LOS was 92 minutes (Interquartile range: 66 minutes). LOS was shorter in: younger patients, those with recurrent dislocations and when analgesics were not given. Use of a lever or traction technique led to increased ED medication use but did not significantly influence ED-LOS.

A systematic review of shoulder reduction success rates without the use of analgesic medication is reported in **chapter five**. Additionally, a discussion of complication risks and the impact of reduction technique on patients' pain experience is included. Randomized and observational studies comparing two or more reduction techniques for anterior shoulder dislocations in the ED , without the use of sedation or intra-articular lidocaine injections, are included. Reduction techniques are grouped as biomechanical reduction technique (BRT), leverage, or traction-countertraction (TCT) technique. Over 2,700 article titles and abstracts were screened. Nine articles, with a total of 987 patients, are included in the analysis. Success rates were 0.80 (95%CI 0.74; 0.85), 0.81 (95%CI 0.63; 0.92) and 0.80 (95%CI 0.56; 0.93) for BRT, leverage and TCT, respectively. No success rate differences were observed between the three different reduction groups. In the network meta-analysis, similar, but more precise effect estimates were found. In a post-hoc analysis, the BRT group was more successful than the combined leverage and TCT group with a relative risk of 1.33 (95%CI: 1.19, 1.48). Patients in the BRT group reported significantly less pain with a VAS difference of -2.8 (95%CI -4.2, -1.4) and -0.3 (95%CI -0.6, -0.1) compared to leverage and TCT, respectively. BRT reductions were successful significantly faster than either leverage or TCT, 53 seconds (95% CI: -76, -30) versus 194 seconds (95% CI: -226, -161). These data suggest that BRT may be the optimal treatment for ASDs given high success rates, less patient discomfort, and shortest performance duration.

A variety of BRT are described. **Chapter six** proposes an RCT protocol whereby different BRTs can be compared. The RCT's results are presented in **Chapter seven**. Three hundred and eight patients were enrolled and divided into two groups based on ability to adduct their injured arms. The arm-adduction-able group contained 134 patients. The arm-adduction-unable group had 174 patients. Patients in the arm-adduction-able group were randomized to treatment with Cunningham, modified Milch, or scapular manipulation. Those in the arm-adduction-unable group were randomized to either modified Milch or scapular manipulation. Primary outcomes were ED LOS and pain during reduction assessed by the numerical pain scale. Secondary outcomes included: reduction time, reduction success rate, use of analgesics or sedatives, and complications. In both groups no differences in ED LOS or reported pain were observed In the adduction-able group. The modified Milch technique had the highest first-reduction-attempt success rate, at 52% (p=0.016). In the adduction-unable group, modified Milch also had the best success rate, of 51%(p=0.040), as a first reduction technique. Complications were not seen with any of the reduction methods used.

VIEWPOINT

As indicated, it is striking that for a condition as common and painful as shoulder dislocation, most research is found methodologically and substantively inconsistent. This thesis conducts a systemic research into the subject of shoulder dislocations using a pragmatic approach. This is particularly relevant since several notable gaps in current knowledge exist. Objective information and prospective validation of outcomes is needed. Literature heterogeneity hampers direct technique comparison and has profound implications for daily emergency medicine practice. It is also unclear whether confounders such as the provision of pain medications, medical staff education, and medical staff experience with certain techniques influence studies and their outcomes.

All this means that informed choices had to be made in this thesis. These choices are guided by daily practice experience since information was found noticeably lacking in the available literature. One example is the experience that analgesics and/or light sedation have limited effects on the pain experienced by the patient in shoulder dislocations but it can hamper a direct comparison of techniques. One clear indication that analgesics have a limited effect is the scant use of analgesia as reported in our survey (Chapter four). Also, the enormous range of analgesics techniques found in the literature gives a possible indication that the successful effect of analgesics in ASD is limited. But on the other hand, in clinical practice we see that the effect of analgesics or light sedation can influence the perception of patient and practitioner on how a procedure went.

As an example, patients, medicated or not medicated with morphine, seem to have notable residual pain while awaiting reduction. However, when morphine has been given, patients may become somewhat sedated and therefore less vocal about pain. They may also object less to movements of their injured extremity. Perhaps too, since practitioners may perceive their patients have less pain, they may be willing to use more force during reductions.

Then too, the role of sedation in shoulder reductions is unclear based on presently available medical literature. This knowledge gap is reflected in medical practice. Some practitioners feel that a sharp increase in pain is acceptable and the risk of, or need for, sedation is not. Others feel just the opposite.

Variations in the clinical experience and knowledge of ED practitioners as well as the waiting time for radiographs and physician examination might have a bigger than expected influence on patient care. In hindsight, the choice of ED LOS as a primary outcome measure may not have been the best as the factors noted above may have had more influence on patients' LOS than a timely, successful and immediately performed shoulder reduction.
The need for well-considered choices within this thesis project, underlines the need for more scientific inquiry on the subject of shoulder reductions and related issues. The combination of available knowledge, even given its limitations, and our investigations have practical implications for the clinical setting and will help determine future research questions and directions.

FUTURE RESEARCH DIRECTIONS

The mechanisms of pain causation in shoulder dislocation are presently unknown. Is acute pain due to: rotator cuff muscle stretching, biceps muscle spasm, overstretching of sensitive neurovascular structures, osseous structure trauma, or a combination of factors. Or are there other issues at work here? Greater understanding in this area may lead to a better comprehension of the factors contributing to BRT's success. Perhaps a more targeted and effective pain management strategy will emerge as well.

A rational and scientifically rigorous comparison of different pain-reduction modalities is needed too. Also, the effect of pain management and sedation on reduction success rates merits further inquiry. Reducing study bias by standardizing pain relief techniques and employing uniform reduction techniques is called for as well. Finally, the effect of various measures on ED LOS and use of hospital resources must be taken into account and further studied.

Many available studies on shoulder reduction lack methodological rigor. Future research should take this into account. The reasons for this are numerous and diverse. They include: lack of comparisons between techniques, inadequate comparisons between techniques, comparisons between unequal groups (experienced practitioners perform technique A, less-experienced practitioners perform technique B), inadequate or absent description of reduction technique performed, the technique described is inconsistent with previous studies, important aspects of the technique are unacceptably modified from the original (e.g. using traction in a relaxation/BRT technique), pain medications are used differently in the study groups being compared, learning curve and practitioner education are not described, pain assessments are made at different times in groups being compared, ED LOS are improperly described and charted or are unavailable. All this means that a limited number of studies are available for proper comparisons. This has been amply demonstrated by our systematic review.

To help correct this information gap we suggest the following:

- Our research found that ED LOS depended almost not at all on reduction success rate, rather it was heavily influenced by other—logistical—factors. Therefore, it's advisable to use reduction success as a primary outcome measure. It is important to monitor and record attempt number and to define what constitutes an attempt. Describing alternative techniques used is relevant as well. Additionally, the effect of learning and experience on performance must be considered when a new technique is introduced or when novice practitioners adopt or attempt an established technique.

- A pragmatic study design, i.e. not randomization, has been proposed by the NEXT study group. This way the difference (heterogeneity) in treatment between hospitals can be used to explore different questions and generate data on clinic practice, helping to move toward more uniform treatment.

- Study techniques should be described and performed uniformly. It is also important that the practitioners in a study possess comparable knowledge and skills in the techniques under study. Expert clinicians are NOT required for every study. Comparing the performance of novices or learners can provide valuable information. But, groups with equivalent knowledge and skills should be compared.

- The biceps' role in maintaining a dislocation is important and may help explain why certain techniques succeed while others fail. The question remains – is biceps relaxation alone enough to achieve reduction? Also, what role does the rotator cuff play in reductions? In normal activity it serves an important function, stability. Does its distortion or dysfunction during dislocation imped or hasten shoulder repositioning?

- We found that with increased patient age reduction becomes more difficult. Clinical experience shows the humeral head is often more medial in aged vs younger patients. We question whether the rotator cuff, due to atrophy or other factors, allows the humeral head to position itself more medially. Further, does this make reduction more complex, more difficult and more likely to fail?

BEST PRACTICE TO THE ED PATIENT WITH AN ANTERIOR SHOULDER DISLOCATION

A shoulder reduction should be done as quickly and as painlessly as possible. Muscle relaxation, a calm cooperative relaxed patient and a calm relaxed and competent practitioner are all important to shoulder reduction success. Patients must be advised to relax. They must also be advised about the events that will occur during reduction attempts. Further, they must be advised that they play a role in achieving reduction success. Patient cooperation, understanding and demeanor all allow the practitioner to tailor a reduction technique to the patient, dependent on: practitioner knowledge and skill, patient level of discomfort, patient arm position and state of mind.

A pain-free or pain-limited BRT is preferred with lever techniques as back-ups. Awareness of anatomy and physiology of the techniques is essential, as is the judgment about when to abandon one approach and attempt another. Knowledge and judgment too are needed about when patients require pain medications and/or sedation to achieve a reduction success.

SUMMARY IN DUTCH – SAMENVATTING IN NEDERLANDS

Tijdens een van mijn eerste diensten als arts-assistent op de spoedeisende hulp (SEH) kwam er een patiënt met veel pijn binnen. Het enige wat hij kon uitbrengen was; "Het is weer mijn schouder". Terwijl de patiënt snel naar een lege brancard werd gebracht, waren de instructies van de dienstdoend SEH-arts duidelijk. We zouden deze schouder uit de kom (schouderluxatie) snel gaan terugplaatsen.

Er werd een kortwerkend opiaat gegeven, een laken werd om de borst van de patiënt geslagen en dat moest ik stevig vasthouden. Terwijl ik de tegendruk gaf, begon de SEH-arts steeds meer te hangen aan de arm van de ontwrichte schouder. Hoewel de patiënt ons smeekte om te stoppen vanwege heftige pijn, gingen we door en stelden de patiënt gerust dat het snel over zou zijn. Na een paar lange minuten hoorde we een duidelijke 'plop' en was er een voelbare klik, wat duidde op een succesvolle terugplaatsing (repositie). De patiënt was direct opgelucht en was erg blij dat zijn schouder terug op z'n plek was gezet. Ik was zeer tevreden met het duidelijk succesvolle resultaat van onze behandeling en ook onder de indruk van alles wat er was gebeurd.

Terwijl ik nog stond bij te komen ontstond er in de teampost een levendige discussie. Want er waren wel vragen of dit nu de beste behandeling was geweest: dit was toch de meeste gangbare manier die zo al jaren plaats vond en ook in de richtlijn was vastgelegd? Of hadden we direct moeten inzetten op een roesje (sedatie) of algehele anesthesie op de operatiekamer bij zoveel pijn voor de patiënt? En geeft dat dan weer niet extra belasting van ziekenhuispersoneel, ruimte en apparatuur, want nu was het toch ook gelukt?
Eén opmerking trok extra mijn aandacht en bleef me bij: "Er zijn technieken die minder pijnlijk zijn. Zou dat niet de optimale oplossing zijn?"

De discussie eindigde niet met consensus over hoe we dit volgende keer moesten doen. Maar voor mij was dit wel het begin van een onderzoek en wetenschappelijke zoektocht naar de behandeling van schouderluxaties op de SEH.

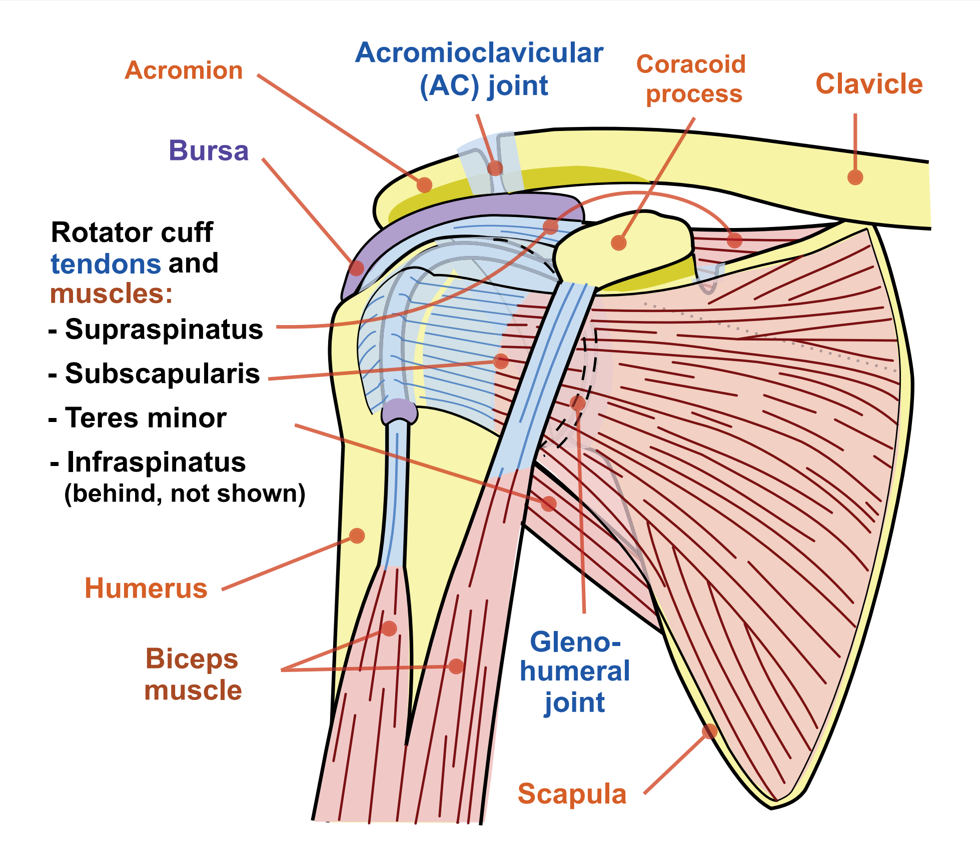
Mijn focus van het onderzoek werd in brede zin: hoe kan een arts een patiënt met een schouder uit de komen het beste, snel en efficiënt, helpen zonder veel extra pijn te veroorzaken, met een minimaal risico op extra schade aan de schouder en terwijl het personeel en apparatuur van de afdeling SEH verstandig worden gebruikt.

Schouder anatomie – een zegen en een vloek

De functie van de schouder in het dagelijks leven is groot en dit is mede te danken aan een enorme mobiliteit. Hierdoor is het mogelijk om met de arm een grote reikwijdte te hebben van extensie, flexie, adductie, abductie en interne en externe rotatie. De ossale anatomie van een relatief grote humeruskop die articuleert met een kleinere benige kom of glenoïd maakt dit mogelijk.

Het enorme bereik van de schouder is tegelijk ook zijn zwakte, waardoor hij vatbaar is voor luxaties. Het labrum draagt bij aan de komvormigheid van het glenoïd en zorgt voor extra stabiliteit. De schouderstabiliteit wordt ook verbeterd door de glenohumerale ligamenten en het gewrichtskapsel. De spieren die voor de stabiliteit zorgen zijn de rotator cuffspieren: musculus supraspinatus, subscapularis, infraspintus en teres minor. De deltoideus zorgt ervoor dat de arm kan worden opgeheven (zie figuur 1). Belangrijke aangrenzende neuro-vasculaire structuren zijn de nervus- en arteria axillaris (oksel zenuw en -slagader).

Figuur 1: Schouderanatomie met botten en spieren die relevant zijn voor schouderluxatie



Hellerhoff, CC BY-SA 3.0, via Wikimedia Commons

Anterieure schouderluxatie – de schouder uit de kom

Bij een anterieure schouderluxatie zijn verschillende structuren acuut overbelast. De cuffspieren waar de meeste rek op ontstaat bij een luxatie zijn de musculus supra- en infraspinatus. Aangenomen wordt dat dit ook de typische pijn veroorzaakt waar patiënten zich mee melden op de SEH, die ze vaak aanwijzen net boven de clavicula (sleutelbeen).

Daarnaast zorgt de meer anterieure (naar voren) positie van de humeruskop tijdens een luxatie ervoor dat er extra spanning komt op de lange kop van de biceps. De pijn die dit veroorzaakt, zorgt waarschijnlijk voor spierspasme van de biceps. Dit draagt bij aan de pijn in de bovenarm tijdens een luxatie, maar maakt een repositie van de schouder ook lastiger, omdat dit spasme ook moet worden overwonnen.

Schouderluxatie, een veel voorkomende diagnose op de spoedeisende hulp

De incidentie van schouderluxaties is ongeveer 23 gevallen per 100.000 personen per jaar, waardoor het wereldwijd de meest voorkomende luxatie is. De piek in de incidentie treedt op bij mannen van 25-30 jaar en vrouwen van 50-70 jaar, met een man-vrouwverhouding van 3:1. De meest voorkomende oorzaken zijn valpartijen en ongevallen met motorvoertuigen. Zeldzaam, maar wel een opvallende groep patiënten, zijn diegenen die een luxatie hebben door een epileptisch insult.

Er zijn drie typen luxatie, waarbij de indeling is op basis van de humeruskop ten opzichte van het glenoïd; anterieur (93-97%), posterieur (1-4%) en erecta (0,5-1%)[1–4] .

Schade door de luxatie

Bij bijna de helft van de anterieure schouderluxaties is de nervus axillaris, en meer specifiek de huidtak naar de musculus deltoideus, bekneld of abnormaal uitgerekt, wat resulteert in neuropraxie[5]. Patiënten geven dan vaak aan tijdens luxatie dat ze een dof gevoel hebben in het gebied van de musculus deltoideus. In meer ernstige gevallen kan de zenuwbeknelling of -beschadiging leiden tot motorische uitval. Er is ook een risico dat tijdens de repositie schade ontstaat aan de nervus axilaris.

Axillaire arteriële compressie is zeldzaam, maar kan leiden tot vasculaire problemen van de arm. Dit herstelt vaak snel als de luxatie is verholpen.

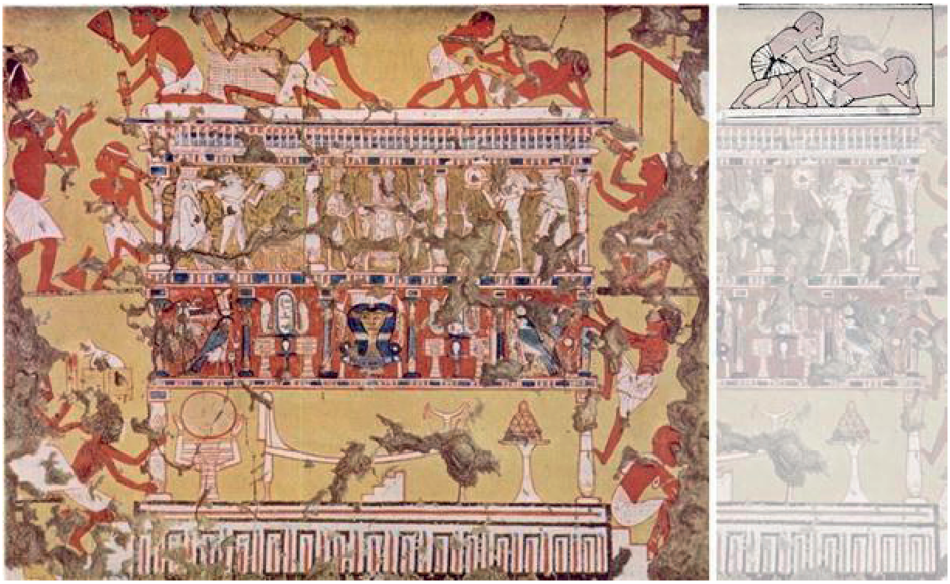
Zowel voor de vermindering van de pijn, maar ook voor het voorkomen van langdurige neurovasculaire schade is een snelle repositie van belang. Over het algemeen wordt aangenomen dat hoe langer de luxatie blijft bestaan, hoe lastiger de repositie gaat worden, mogelijk als gevolg van toegenomen spierspasmen. Dit is echter een proces wat niet uitgebreid is onderzocht.

Een chronische of langdurige luxatie (dagen) kan door de druk op het kraakbeen en bot zorgen voor irreversibele ossale schade aan het gewricht.

Verschillende technieken

Waarschijnlijk werden, vanwege de acute pijn, al ver voor het ontstaan van de moderne geneeskunde schouders gereponeerd. Er is al een repositietechniek te zien in een grafkelder in het oude Egypte, die lijkt op de techniek die later door Kocher in begin 20ste eeuw wordt beschreven (zie figuur 2)[6].

Figuur 2: Muurschildering met mogelijk een schouder repositietechniek uit een Egyptische tombe



Tomb of Ipuy, wall painting (~1200 B.C.) Reproductie van: Davies, N. de Garis. Two Ramesside Tombs at Thebes. Robb de Peyster Tytus Memorial Series, Volume V. 1927. New York, The Metropolitan Museum of Art. (Plate XXXVIII)

De naam die historisch het meest verbonden is met schouderluxaties is die van Hippocrates, die tijdens zijn leven al 7 technieken heeft beschreven. In de eeuwen daarna zijn er nog diverse technieken beschreven of bijzondere werktuigen bedacht (figuur 3). Tegenwoordig komt een schatting uit op in elk geval meer dan 50 technieken en varianten.

Figuur 3: Lijntekening uit de 16e eeuw met een schouder repositietechniek

Les œuvres de M. Ambroise Paré ... Avec les figures et portraicts tant de l'anatomie que des instruments de chirurgie, et de plusieurs monstres. Le tout divisé en vingt six livres., Paré, Ambroise, 1510?-1590.

De dagelijkse praktijk

Een patiënt met een schouderluxatie heeft snel medische hulp nodig. Idealiter wordt de repositie snel uitgevoerd, terwijl het reponeren beperkt en aanvaardbaar (extra) pijn voor de patiënt veroorzaakt, met zo min mogelijk kans op nieuwe complicaties door het reponeren zelf.

In Nederland melden de meeste patiënten zich voor de benodigde hulp op de SEH. Voor de SEH is het belangrijk dat de repositie naast bovenstaande snelle en pijnloze uitvoering, gedaan kan worden met zo weinig mogelijk inzet van extra middelen, om de werkdruk en belasting van de SEH zo klein mogelijk te houden. Als de patiënt weer snel naar huis kan, is dat niet alleen fijn voor de patiënt maar zorgt ook voor minder overmatige drukte (crowding) op de SEH.

Patiënten met een luxatie hebben veel pijn, daarom is pijnstilling vaak de eerste behandeling. De uitdaging hierbij is dat de verschillende pijnstillingsmiddelen bij schouderluxaties niet goed zijn onderzocht. Een extra complicerende factor is dat de repositietechniek zelf ook invloed heeft op hoeveel pijn de patiënt ervaart. Als laatste is de interactie tussen pijnstillings- en repositietechniek en invloed van de behandelaar daarop grotendeels onbekend.

Pijnstilling

In het ideale geval zou de medicatie die wordt gebruikt bij een schouderrepositie snel en kortwerkend moeten zijn, zodat de patiënt ook weer snel naar huis kan als de repositie is gelukt. Een uitdaging bij de keuze voor type pijnstilling en techniek van toediening is dat het onderzoek dat is gedaan vaak minder goed bruikbaar is, omdat er weinig rekening is gehouden met de invloed van repositietechniek of behandelaar op de pijn.

Medicatietoedieningsmethoden en effectiviteit

Het doel van de pijnstilling is dat deze in elk geval snel werkt. Dit maakt het gebruik van orale medicatie voor het acute moment beperkt, de effecten van paracetamol of niet-steroïde ontstekingsremmers (NSAID) zijn pas na 30 minuten te verwachten. Snelwerkende opioïden lijken geschikter en kunnen intraveneus of nasaal worden toegediend. Het analgetische effect van bijvoorbeeld fentanyl blijkt echter te weinig te zijn.

Zenuwblokkades zorgen op efficiënte wijze voor pijnverlichting. Deze hebben echter teveel tijd nodig om te werken - 15 tot 45 minuten, en om te plaatsen - en dragen hierdoor aanzienlijk bij aan de verblijfsduur op de SEH.

Intra-articulaire lidocaïne (IAL) wordt veel gebruikt. Afgezien van de tijd die nodig is tot dit effect heeft, 15 tot 20 minuten, concludeerden twee grote onderzoeken dat het een redelijke pijnstillingsoptie is[78]. In de dagelijkse praktijk lijkt de pijnreductie toch beperkt en er zijn dan ook wat vragen over de geïncludeerde studies. Deze gebruiken bijvoorbeeld geen uniforme repositietechniek, wat de vergelijkingen tussen de groepen beperkt. Bovendien werden benzodiazepines en andere sedatiemethoden gebruikt in anxiolytische (angstdempende) doseringen en niet op een manier gebruikelijk voor milde of diepe procedurele sedatie en analgesie (PSA)[9].

De laatste optie is PSA (roesje), dit werkt snel, zorgt voor pijnverlichting, sedatie, spierontspanning, het zorgt ervoor dat de patiënt de repositie goed kan verdragen en zelfs vaak de procedure een beetje vergeet. Een bijkomend voordeel is dat verschillende PSA-middelen kortwerkend en van korte duur zijn.

Vergelijkende onderzoeken van hoge kwaliteit tussen PSA en andere pijnbehandelings-strategieën of placebo ontbreken echter. Ook vergt de techniek wel enige voorbereiding en voor de medicatietoediening is extra tijd en personeel nodig om de PSA correct en veilig uit te voeren. Na de PSA moet de patiënt ook enige tijd worden geobserveerd, wat extra tijd toevoegt aan de verblijfsduur op de SEH. Tenslotte kunnen niet alle repositietechnieken veilig worden uitgevoerd bij de licht- tot diep gesedeerde patiënt. Ondanks deze nadelen blijft PSA een goede optie voor patiënten die een schouderrepositie nodig hebben. PSA wordt voor deze indicatiewereldwijd zeer frequent en veilig gebruikt.

Mogelijke alternatieven

Gezien de hierboven geschetste beperking van succesvolle pijnbestrijding met medicatie, zou de beste benadering zijn om een repositietechniek of een groep technieken te gebruiken die minimale tot geen pijn veroorzaken, en daarom geen extra pijnstilling vereisen. Dit zou het mogelijk te maken de repositie beter te ondergaan.

Repositietechnieken en moeilijkheden bij het vergelijken van resultaten

Zoals eerder beschreven worden er in de medische literatuur meer dan 50 verschillende repositietechnieken beschreven, zelfs nog meer als alle varianten van deze technieken worden meegerekend. Directe wetenschappelijke vergelijking van deze technieken is moeilijk. Onder andere doordat in veel studies de beschrijving van de repositietechniek en/of de gebruikte pijnstillingsmethoden onvolledig is. Ondanks eenzelfde naam worden technieken anders beschreven en worden daadwerkelijke bewegingen die tijdens reposities worden uitgevoerd, onvolledig of onduidelijk beschreven.

Repositietechnieken - algemeen werkingsmechanisme

Op basis van hun werkingsmechanisme kunnen de verschillende technieken in drie groepen worden ingedeeld:

- Tractie/Tegentractie:

Bij deze technieken wordt tractie toegepast die de spierspanning overtreft, waardoor er repositie optreedt.

Hippocrates beschreef voor het eerst een techniek van tractie/tegentractie. Bij zijn meest bekende methode trekt de behandelaar aan de arm van de patiënt, terwijl hij tegendruk uitoefent door zijn hiel in de oksel van de patiënt te plaatsen. Hij beschreef ook al een techniek waarbij er tegenkracht wordt geboden door een laken rond de borst van de patiënt te wikkelen en tegen de richting van de tractie op de arm in te trekken, een nu nog steeds veel gebruikte techniek. Zo is mijn interesse voor dit onderzoek ontstaan.

Er bestaan echter nog vele andere tractie-/tegentractievarianten, waaronder: Stimson, Eskimo-technique, Chair technique, Snowbird, Sosmat, Spaso, SRT, forward elevation and auto-reduction methods[10,11]. Alle tractie-/tegentractietechnieken vereisen doorgaans enige pijnstilling omdat overwinnen van de spierspanning door kracht extra pijn veroorzaakt. Bij sommige van deze tractie technieken zijn ook risico's op neurovasculaire schade of fracturen beschreven.

8

- Hefboomtechnieken:
Door de arm te bewegen kan er een hefboom worden gemaakt tussen het glenoïd en de humeruskop, wat leidt tot repositie. Rond 1870 beschreef Kocher de bekendste van deze technieken, die nog steeds zijn naam draagt. Andere voorbeelden van hefboomtechnieken is de externe rotatie techniek. Er is een risico op het veroorzaken van een fractuur bij een hefboomtechniek.

Deze technieken kunnen pijnlijk zijn en daardoor is soms extra pijnstilling nodig. Dit is ook afhankelijk van de uitvoering en de coöperatie van de patiënt.

- Biomechanische technieken
Hierbij ligt de focus op het bevorderen van spierontspanning. Door het verminderen van spierspanning en spasmen kan er een repositie optreden doordat de schouder terugkomt in zijn normale positie. Het is dan ook belangrijk om de patiënt op zijn gemak te stellen. Bij de meeste van deze technieken wordt de patiënt in zittende positie gevraagd zijn schouders op te halen en de schouder naar achteren te bewegen alsof hij zijn schouder naar achteren rolt. Aangenomen wordt dat dit meer ruimte in het schoudergewricht creëert en spierontspanning bevordert.

De technieken gebruiken aanvullende strategieën om spierspanning te verminderen. Bij de Cunningham-techniek wordt de elleboog gebogen en dicht bij het lichaam geplaatst (adductie). Dit vermindert de spierspanning van de biceps en brengt de humeruskop dichter bij het glenoïd.

In de Milch-techniek en zijn varianten, zoals FARES, wordt repositie bereikt door exorotatie van de schouder terwijl de arm ongeveer 130 graden in abductie wordt gebracht. Dit zorgt voor spierontspanning van de musculus supraspinatus- en infraspinatus. Door de positionering van de arm en de schouder kunnen de biceps en triceps de humeruskop in het glenoïd trekken.

Bij scapuliermanipulatie wordt het schouderblad, niet de arm, bewogen. Daarbij beweegt het glenoïd in de richting van de geluxeerde humeruskop en vindt repositie plaats.

Omdat de biomechanische technieken de spanning op gespannen, uitgerekte en pijnlijke structuren minimaliseren en zich richten op spierontspanning en ontspanning van de patiënt, is extra pijnstilling zelden nodig als de technieken correct worden uitgevoerd.[12–16]

Centrale vraag in dit proefschrift

De uitdagingen zoals hierboven beschreven hebben geleid tot de centrale vraag in deze thesis: Wat is de voorkeurstechniek voor het verminderen van een anterieure schouderluxatie zonder het gebruik van extra pijnstillende technieken?

Resultaten

In **hoofdstuk 2** beschrijven we de hoe de acute behandeling van schouderluxaties past in een langer poliklinisch behandeling. De adequate behandeling van schouderluxaties is gericht op het voorkomen van recidiverende luxaties, om zo klachten en daarmee ook maatschappelijke kosten te voorkomen. Patienten met een eerste luxatie blijken in het vervolg traject niet altijd voldoende informatie te krijgen over de verschillende behandelingen, waarbij rekening kan worden gehouden met operatieve dan wel fysiotherapeutische behandelingen. Gezamenlijke besluitvorming is hierin belangrijk omdat behandeling aan moet sluiten bij de wensen en verwachtingen van de patiënt

Om te weten wat er gebeurt in de huidige praktijk is er informatie nodig over het gebruik van de verschillende technieken. Hiervoor hebben we in **hoofdstuk 3** een enquête gedaan onder behandelaars, werkzaam op de spoedeisendehulp. Wij wilden weten welke technieken als eerste keuze werden gebruikt, welke complicaties er werden gezien en welke pijnstilling werd gebruikt. Deze enquête is verspreid via de Nederlandse Vereniging van Spoedeisende Hulp Artsen onder zijn leden. Uit de resultaten bleek dat 44% van de respondenten een tractie-methode gebruikte, biomechanische technieken werden gebruikt door 40%, in ongeveer 12% werd een hefboom-techniek gebruikt en bij 5% van de respondenten was de techniek niet te kwalificeren. Over complicaties konden de respondenten geen eenduidig antwoord geven. Als pijnstilling werd een breed scala genoemd, waarbij een opiaat of procedurele sedatie middels propofol het meest werd gebruikt. Het succes- percentage werd door een groot deel van de respondenten als zeer hoog ingeschat. Deze enquête liet zien dat ook in de dagelijkse praktijk weinig eenduidigheid is in de gebruikte technieken.

Om de implicaties van de verschillende factoren die de verblijfsduur op de SEH beïnvloeden te duiden hebben we daar naar gekeken in **hoofdstuk 4** middels een retrospectief onderzoek bij twee ziekenhuizen. In dit onderzoek hebben we data verzameld van alle patiënten ouder dan 12 jaar die zich melden met een schouderluxatie op de SEH van twee regionale ziekenhuizen in Nederland tussen 2010 en 2016. De elektronische patiëntendossiers werden beoordeeld op patiëntkenmerken zoals traumamechanisme, repositiemethoden, medicatiegebruik, complicaties en de verblijfsduur op de SEH.

In de onderzoeksperiode waren er 716 anterieure schouderluxaties gezien bij 574 patiënten, waarvan 374 (65,2%) bij mannen. Er waren 389 (54,3%) primaire anterieure schouderluxaties;

de andere (327, 45,7%) waren een recidief. Gemiddeld bleven patiënten 92 minuten op de SEH, waar bij patiënten met een recidief, jongere leeftijd en geen medicatiegebruik dit verblijf korter was. Het gebruik van een tractie- of hefboom-techniek zorgde voor meer medicatiegebruik, echter werd dat verschil niet terug gevonden in de duur van het verblijf op de SEH.

In **hoofdstuk 5** hebben we gekeken of in de literatuur duidelijk was welke groep technieken zonder gebruik van medicatie het beste repositie succes had en waarbij de pijnbeleving voor de patiënt niet toenam. Ook wilden we weten of er technieken waren met een hoger complicatie-risico. Hiervoor hebben we een literatuuronderzoek gedaan naar gerandomiseerde en observationele studies waarbij twee of meer gesloten repositietechnieken voor anterieure schouderluxaties op de SEH werden vergeleken zonder gebruik van sedatie of intra- articulaire lidocaïne-injecties.

We hebben de technieken daarna ingedeeld op basis van hun werking in een tractie-tegentractie (TCT), hefboomwerking (leverage) en biomechanische (BRT) groep. In totaal zijn er 2702 artikelen gescreend op titel en abstract, waarvan 9 artikelen werden geïncludeerd, met in totaal 987 patiënten. De succespercentages van de verschillende groepen was 80% voor TCT, 81% voor leverage en 80% voor BRT. Er waren statistisch ook geen verschillen in succespercentages tussen de drie afzonderlijke groepen. In een netwerk meta-analyse van het repositie succes werden dezelfde, maar duidelijkere effecten gevonden. In een extra analyse bleek dat de BRT-groep 33% succesvoller was dan de gecombineerde resultaten van leverage- en TCT-groep. De repositie in de BRT-groep was minder pijnlijk met een verschil in pijnscore (VAS gaat van 1-10) van -2.76, vergeleken met -0.34 en 0.05 bij de leverage en TCT. BRT was ook 53 seconden sneller dan leverage en 194 seconden sneller dan TCT. Deze studie suggereert dat BRT de beste resultaten lijkt te hebben voor repositietechnieken bij anterieure schouderluxatie, succesvol, met de minste pijn en met een snel resultaat.

De groep van biomechanische technieken is divers, met nog weinig inzicht in wat de beste techniek is binnen deze groep. In **hoofdstuk 6** beschrijven wij dan ook een protocol van een gerandomiseerde studie waarin we verschillende biomechanische technieken met elkaar vergeleken. De resultaten van deze RCT staan in **hoofdstuk 7** beschreven. In deze studie werden 308 patiënten geïncludeerd. Deze zijn verdeeld op basis van lichamelijk onderzoek in twee groepen, een groep waarin adductie van de arm mogelijk was met 134 patiënten en een groep waarin dit niet mogelijk was van 174 patiënten. Patiënten die adductie van de arm konden uitvoeren, werden gerandomiseerd voor Cunningham, de gemodificeerde Milch en de scapulaire manipulatietechniek. Degenen die niet konden adduceren, werden gerandomiseerd toegewezen aan gemodificeerde Milch en de scapulaire manipulatietechniek.
Primaire uitkomstmaten waren de duur van het verblijf op de spoedeisende hulp en de pijn die werd ervaren tijdens het repositieproces, gemeten met de numerieke pijnbeoordelingsschaal.

Secundaire uitkomsten waren repositietijd, repositiesucces, gebruik van pijnstillers of sedativa en complicaties. In beide groepen werden geen verschillen in de duur van het verblijf op de spoedeisende hulp en ervaren pijn waargenomen tussen de behandelarmen. In de adductiegroep had de gemodificeerde Milch-techniek de hoogste slagingspercentages voor de eerste repositie 52% (p=0,016). In de groep zonder adductie was de gemodificeerde Milch ook de meest succesvolle primaire repositietechniek met 51% succes (p=0,040). Bij geen van de technieken werden complicaties geregistreerd.

CONCLUSIE VOOR DE PRAKTIJK

Een repositie bij een schouderluxatie moet zo snel en zo pijnloos mogelijk gebeuren. Spierontspanning, een kalme, coöperatieve, ontspannen patiënt en een kalme, ontspannen en competente behandelaar zijn allemaal belangrijk voor het succes van schouderrepositie. Patiënten moeten worden begeleid in het zo goed mogelijk ontspannen. Ze moeten daarvoor worden geïnformeerd over de gebeurtenissen die zullen of kunnen optreden tijdens repositie. Medewerking, begrip en houding van de patiënt stellen de behandelaar in staat om een repositietechniek op de patiënt af te stemmen, afhankelijk van kennis en vaardigheid van de behandelaar, mate van ongemak bij de patiënt, positie van de arm van de patiënt en gemoedstoestand.

Kennis van de anatomie en fysiologie van de schouderluxatie en de invloed van de verschillende technieken hierop is essentieel, evenals het kunnen maken van de inschatting wanneer een benadering moet worden opgegeven en een alternatief moet worden geprobeerd. Ook kennis en beoordelingsvermogen zijn nodig over wanneer patiënten pijnmedicatie en/of sedatie nodig hebben.

Een biomechanische repositie techniek die pijnloos of minimaal pijnlijk is, heeft de voorkeur als eerste keuze met de hefboomtechnieken als tweede mogelijkheid.

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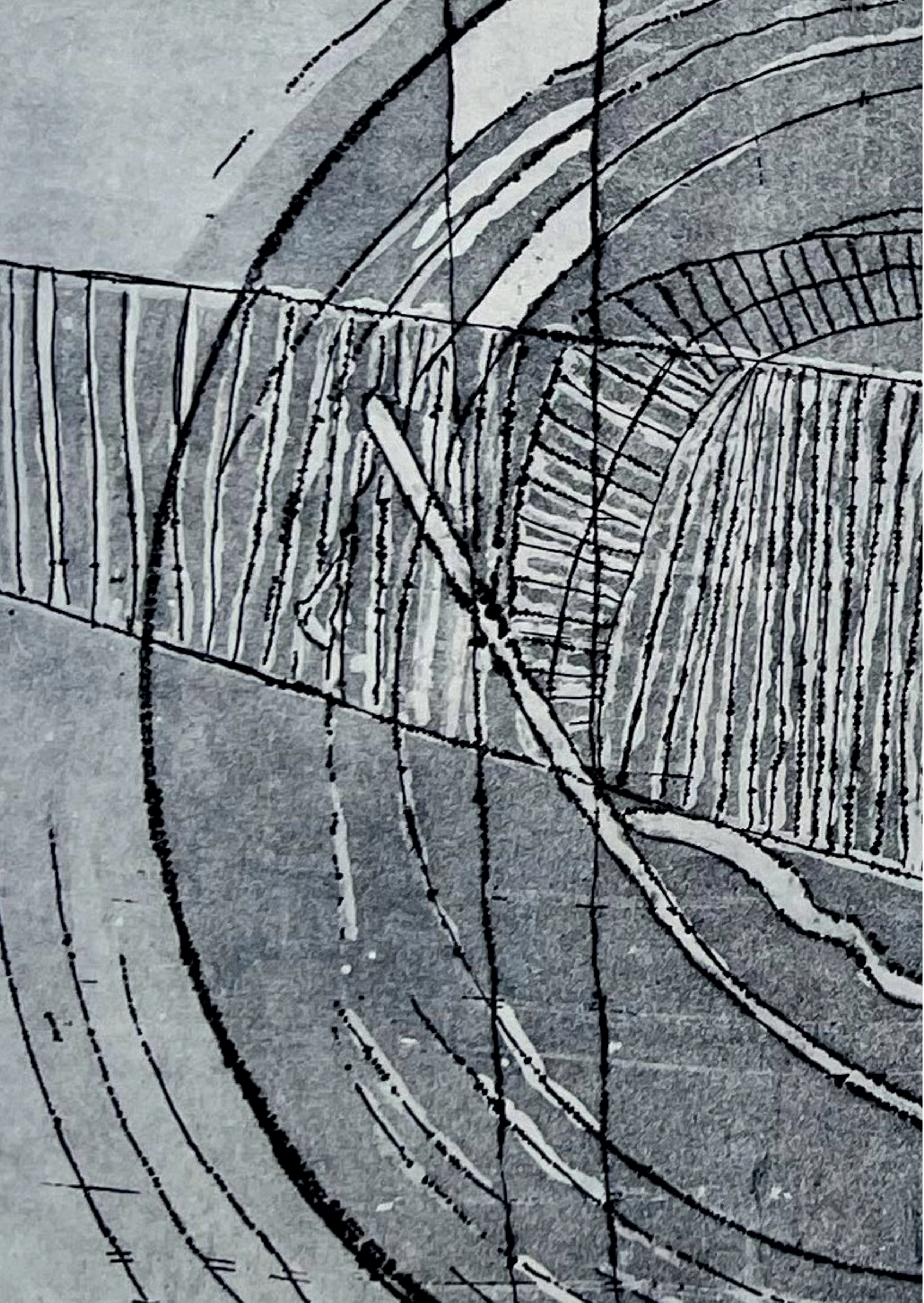

APPENDICES

List of publications
Curriculum Vitae
Acknowledgments in Dutch – Dankwoord

LIST OF PUBLICATIONS

- KM Lommerse, SYM Mérelle, D de Beurs, M Fuchs, **DN Baden.** Suïcidaal gedrag op de SEH - 10 tips voor een actieve, betrokken en preventieve aanpak. Ned Tijdschr Geneeskd. 2023;167:D7535

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CURRICULUM VITAE

David Nico Baden was born in 1981 in Ede. In 1999 he obtained his VWO diploma at Marnix College. Because he was not accepted for medicine, he started with Dutch Law at the University of Utrecht, where he obtained his propaedeutic certificate in 2002. In the same year he was admitted to medicine at the VU University in Amsterdam. During his studies in law and medicine he also did many other activities, both with his friends and fraternity, but also in the organization of the 120th student rowing competition 'the Varsity', the lustrum competitions of the USR 'Triton'. And worked as a cook and bartender.

In 2011 he completed his medical training, with an elective internship in surgery at Mount Sinai Hospital in New York, an elective internship in pediatric endocrinology and senior internship in pediatric surgery, both at VUmc. After this he started as a resident in surgery at the Flevoziekenhuis and Slotervaart, followed by a residency at the ER of the Flevoziekenhuis.

He started in 2015 as a resident in training to become an emergency physician at the Westfriesgasthuis (Dijklander) in Hoorn. After completing his education in 2018, he started as an emergency physician in the Diakonessenhuis in Utrecht.

During his education, he started his research in shoulder dislocations in 2015.

In addition, he has also become increasingly active as a board member, first as chairman of the guideline committee of the Dutch Society of Emergency Physicians (DSEP/NVSHA), from 2016 on the board as the quality chair and from 2020 as president of the society. In these various roles, he has been involved in the development of a large number of quality documents, such as kwaliteitskader spoedzorgketen, chair of the workgroup 'taakherschikking VS en PA SEH', advice from the health council on the 'heroverweging van de 45 minutennorm', during the COVID-19 pandemic the guideline 'Triage op basis van niet-medische overwegingen voor IC-opname ten tijde van fase 3 (code zwart) and also the new guideline 'shoulder dislocations'

David is the initiator in starting the Dutch version of the APEx course, a course started in England for the structured care of acutely confused and suicidal patients, in order to stimulate the collaboration between the physical and mental medical domain. He is also involved in the implementation of the digital data exchange in acute care, including as chairman of the expert group of the project "Met Spoed Beschikbaar".

In his spare time, David enjoys visiting the theater and cabaret, visiting museums, cooking, fine dining, playing golf and gardening.

CURRICULUM VITAE IN DUTCH

David Nico Baden werd in 1981 geboren in Ede. In 1999 behaalde hij zijn VWO diploma op het Marnix College. Omdat hij niet ingeloot werd voor geneeskunde, startte hij met Nederlands Recht aan de universiteit van Utrecht, waarvan hij in 2002 zijn propedeuse behaalde. In datzelfde jaar werd hij toegelaten tot geneeskunde aan de Vrije Universiteit in Amsterdam. Tijdens zijn studie rechten en geneeskunde heeft hij ook veel andere activiteiten gedaan, zowel met zijn vrienden en jaarclub, maar ook in de organisatie van 120ste studentenroeiwedstrijd de Varsity, de lustrumwedstrijden van de USR Triton. En gewerkt als kok en barman.

In 2011 ronde hij zijn geneeskunde opleiding af, met een keuze co-schap chirurgie in het Mount Sinai Hospital in New York, een keuze co-schap kinderendocrinologie en oudste co-schap kinderchirurgie, beiden in het VUmc. Hierna is hij begonnen hij als arts-assistent chirurgie in het Flevoziekenhuis en Slotervaart, met daarna nog een arts-assistentschap op de SEH van het Flevoziekenhuis.

Hij is in 2015 begonnen als arts-assistent in opleiding tot spoedeisende hulp arts in het Westfriesgasthuis (Dijklander) in Hoorn. Na het afronden van zijn opleiding in 2018 is hij begonnen als SEH-arts KNMG in het Diakonessenhuis in Utrecht.

Tijdens zijn opleiding is hij in 2015 gestart met zijn onderzoek naar schouderluxaties. Daarnaast is hij ook bestuurlijk steeds meer actief geworden, eerst als voorzitter van de richtlijncommissie van de Nederlandse vereniging van spoedeisende hulp artsen (NVSHA), vanaf 2016 in het bestuur als portefeuillehouder kwaliteit en vanaf 2020 als voorzitter van de NVSHA. In deze verschillende rollen is hij betrokken geweest bij de ontwikkeling van een groot aantal kwaliteitsdocumenten zoals het kwaliteitskader spoedzorgketen, voorzitter werkgroep taakherschikking VS en PA SEH, advies van de gezondheidsraad over de heroverweging van de 45 minuten-norm, tijdens de COVID-19 pandemie de ontwikkeling van draaiboek 'Triage op basis van niet-medische overwegingen voor IC-opname ten tijde van fase 3 (code zwart)' en ook de nieuwe richtlijn schouderluxaties.

Hiernaast is David de initiatiefnemer van de Nederlandse APEx cursus, een cursus uit Engeland voor de gestructureerde opvang van acute verwarde en suïcidale patiënten, om zo de samenwerking tussen het lichamelijke en geestelijke medisch domein te verbeteren. Ook is hij betrokken bij de implementatie van de richtlijn 'digitale gegevensuitwisseling acute zorg' onder andere als voorzitter van de expertgroep van het project "Met spoed beschikbaar".

In zijn vrije tijd houdt David van het bezoeken van het theater en cabaret en musea, koken, uit eten gaan, golfen en tuinieren.

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Ik wil ook graag mijn opleiders uit het Westfriesgasthuis (nu Dijklander) **Nieke Mullaart Jansen en Tom Boeije** bedanken voor hun vertrouwen, dat ik tijdens mijn opleiding tijd kon besteden aan het uitwerken en opzetten van een multi-centrum RCT vanuit een perifeer ziekenhuis. Maar ook voor hun hulp bij het opzetten van deze studie, het meelezen van METC aanvragen en het regelen van inclusies.

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"Ik wil voorkomen dat we mensen de meer-zorg-fuik in leiden, maar uit onzekerheid zeg ik soms ook: doe toch maar alles." – eigen werk, Arts & Auto (2023)