The accuracy of trained nurses in pre-operative health assessment: results of the OPEN study

W. A. van Klei,[1] P. J. Hennis,[2] J. Moen,[3] C. J. Kalkman[4] and K. G. M. Moons[5]

1 Resident in Anaesthesiology/Clinical Epidemiologist, 2 Anaesthetist, 3 Research Nurse, 4 Professor of Anaesthesiology/Clinical Epidemiologist, 5 Associate Professor of Clinical Epidemiology, Department of Perioperative Care and Emergency Medicine, University Medical Centre Utrecht, 3508 GA Utrecht, The Netherlands

Summary

We quantified the accuracy of trained nurses to correctly assess the pre-operative health status of surgical patients as compared to anaesthetists. The study included 4540 adult surgical patients. Patients' health status was first assessed by the nurse and subsequently by the anaesthetist. Both needed to answer the question: 'is this patient ready for surgery without additional work-up, Yes/No?' (primary outcome). The secondary outcome was the time required to complete the assessment. Anaesthetists and nurses were blinded for each other's results. The anaesthetists' result was the reference standard. In 87% of the patients, the classifications by nurses and anaesthetists were similar. The sensitivity of the nurses' assessment was 83% (95% CI: 79–87%) and the specificity 87% (95% CI: 86–88%). In 1.3% (95% CI: 1.0–1.6%) of patients, nurses classified patients as 'ready' whereas anaesthetists did not. Nurses required 1.85 (95% CI: 1.80–1.90) times longer than anaesthetists. By allowing nurses to serve as a diagnostic filter to identify the subgroup of patients who may safely undergo surgery without further diagnostic workup or optimisation, anaesthetists can focus on patients who require additional attention before surgery.

Keywords *Anaesthesia*; pre-operative assessment. *Manpower*; anaesthetists, nurses.

Correspondence to: Dr Wilton A. van Klei
E-mail: w.a.vanklei@azu.nl
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Detection of comorbidity in surgical patients at the time of pre-operative evaluation allows optimisation of the patients' condition and selection of an appropriate anaesthetic strategy [1]. Traditionally, patients were visited on the ward by the anaesthetist in the late afternoon the day before surgery, but this practices results in late cancellations of surgery if significant comorbidity is present. Outpatient pre-operative evaluation (OPE) some weeks before surgery potentially reduces morbidity, prevents late operating room cancellations, and allows surgery after same day admission and day case surgery [2–6].

The introduction of OPE clinics requires an increase in the number of anaesthetists. Otherwise, in the setting of a global shortage of anaesthetists, the provision of OPE will reduce the capacity to provide operating room anaesthesia. Moreover, most surgical patients are relatively healthy and may not need an assessment by a medical specialist, whereas the more diseased surgical patients may receive inadequate attention due to lack of time and resources. Therefore, in some clinics, nurses have been involved in OPE as a substitute for anaesthetists [2,7–11]. Only one small study has quantified the performance of nurses in pre-operative evaluation compared to anaesthetists [7]. Other studies have used preregistration house officers as the reference standard to compare the performance of nurses [8,10]; such comparisons do not represent current practice in which anaesthetists are the best available reference test to be used in diagnostic accuracy research [12–14].

We hypothesised that trained nurses would be able to classify the pre-operative health status of most patients similarly to anaesthetists, and that the number of patients incorrectly classified as 'ready for surgery' would be low. The OPEN study (Outpatient Preoperative Evaluation by Nurses) was designed as a diagnostic study to quantify the accuracy of nurses to correctly assess the patients' health status before surgery compared to assessment by anaesthetists. Specifically, we quantified whether the nurses were able to discriminate patients who are ready for surgery from those that need further assessment and work-up by the anaesthetist and/or other specialists.

Methods

Participants

The OPEN study was performed at the University Medical Centre Utrecht, a 1080 bed teaching hospital in which all types of surgery are performed. The study included adult, non-cardiac surgery patients who visited the OPE clinic between 12 February 2002 and 28 February 2003 and was approved by the hospital ethics committee. Patients were included after written informed consent had been obtained.

Standard OPE clinic protocol in our hospital

On average, 3 weeks before surgery, all non-emergency patients visit the OPE clinic, either by advanced appointment, or on a walk-in basis directly after visiting the surgeon. Each patient fills in a health questionnaire as a first screening for comorbidity. The anaesthetist reads the medical record, including referral letters, to obtain information about previous diseases. Subsequently, a history is taken and physical examination is performed. Additional investigations (e.g. laboratory tests) and specific treatment (e.g. beta-adrenergic blockade or bronchodilator therapy) are initiated only if considered necessary for the planned surgical procedure and anaesthetic technique. In patients over 60 years of age, renal function tests and electrocardiography are performed routinely. Finally, patients are informed about the anaesthetic strategy and informed consent for anaesthesia is obtained. All patient data are stored in an Electronic Patient Record (EPR) system. The OPE clinic is staffed by a consultant anaesthetist and two residents in anaesthesiology, who are able to perform a health assessment without direct supervision. The doctors are supported by three nurses and three medical receptionists. Every day approximately 35 adult, non-cardiac surgery patients visit the OPE clinic.

Training of nurses

All participating nurses had at least 5 years nursing experience in the post anaesthesia care unit (PACU) or ICU. Before the study, they were trained in medical history taking and physical examination, including auscultation of heart and lungs. They received lectures on cardiovascular, lung, liver and endocrine diseases, renal insufficiency, allergies, obesity, 'the elderly patient' and the American Society of Anesthesiologists (ASA) classification [15,16]. Because auscultation of heart and lungs is difficult and requires experience, the decision to refer surgical patients for echocardiography was always made by the anaesthetist. The nurses were only trained to distinguish between 'normal' and 'abnormal' sounds and were not trained to further classify the murmurs. Accordingly, when nurses detected any sound different from normal heart and breath sounds, they had to classify a patient as 'not ready for surgery' (see primary outcome definition below).

The four-month training period of nurses was completed after success in an in-house examination.

Study design and procedures

Since the research question was quantification of the diagnostic accuracy of a particular test (trained nurses) as compared to the optimal existing reference (anaesthetists), we selected the most efficient and valid design. This has been shown to be a non-randomised cross-sectional design rather than a randomised longitudinal design [12,13,17–19]. In the present study, this meant that each patient was first assessed by the nurse and subsequently by the anaesthetist.

The health assessment by the nurse included judgment of the health questionnaire on the EPR, in which a window with predefined additional questions automatically 'popped-up' on screen if a patient's answer was suggestive of underlying disease. These questions were mandatory and aimed to help the nurse to determine whether any comorbidity was present. For example, if a patient's answer was suggestive for coronary artery disease (angina), six additional binary questions popped up: 'Is the pain located retrosternally?'; 'Does it appear during exercise, in a cold environment or during strong emotions?'; 'Does it appear during rest?'; 'Is it referred to other regions (e.g. left arm)?'; 'Are there any changes during the last 6 months (stable angina or not)?'; 'Is it already treated by a cardiologist or general practitioner?' After the patient history, the nurse performed a standardised physical examination including automated blood pressure, height and weight measurement, evaluation of the airway, and auscultation of heart and lungs. Finally, the nurse classified each patient according to the study outcomes (see below).

After the nurse's health evaluation, each patient visited the anaesthetist or resident, who also assessed the patient's health status using the same instruments (health questionnaire, additional history, and physical examination) and classified each patient according to the study outcomes. The anaesthetist was blinded for the health measurement results and final classifications of the nurse. After completion of the health assessment, the anaesthetist informed the patient of the anaesthetic strategy and obtained informed consent for anaesthesia.

Outcomes

The primary study outcome was the answer to the question: 'Is this patient ready for surgery without additional testing or work-up (Yes or No)?' This question needed to be answered in the absence of routine additional test results, i.e. 'Is this patient ready for surgery provided that the additional tests are normal?' The primary outcome can be easier expressed as: 'ready for surgery' or 'not ready, needs work-up'. Both the nurse and the anaesthetist answered this question for each patient. The physician also indicated the reason (cardiac, high blood pressure, pulmonary, endocrine, or other) if the answer was 'no'.

Secondary study outcomes were the ASA classification and the time required to complete the health assessment including the time required to read the medical record. The time required by the anaesthetist to educate the patient about the anaesthetic strategy and to obtain informed consent was not included to allow for valid comparisons, as these aspects were not included in the health assessment of the nurses.

Data collection

For logistical reason, in the first four months of the study, only patients with an appointment at the OPE clinic were asked to participate. This resulted in 27% participations in the first four months (600/2189). After 1 June 2002, all patients were asked to participate, resulting in 68% (3940/5777) participations. Most patients who refused participation said that they considered the time required for the extra health assessment by the nurse (about 20 min) too long and preferred to be assessed by the anaesthetist only. All study data could be selected from the EPR, which was modified specifically for the study. For example, simply entering data automatically stored the 'start' and 'end' times necessary for the secondary outcome.

Analysis

To determine whether the study population was representative for all adult non-cardiac surgery patients, the characteristics of the participating patients were compared to those who did not participate – either for logistical reasons or because they refused participation. Analysis of the primary outcome was expressed in a two by two table, comparing the health assessment by nurses to the anaesthetists' health assessment. Following recent methodological guidelines on diagnostic accuracy research, the anaesthetists' health assessment was used as the reference standard as it can be considered as the best available reference in current practice [12–14]. All diagnostic parameters (predictive values, sensitivity and specificity) with 95% confidence intervals were estimated. The characteristics of patients classified by the nurse as 'ready for surgery' but classified by the anaesthetist as 'not ready, needs work-up' are described extensively because this patient group should be as small as possible. In a nurse based OPE clinic, these patients would be scheduled for surgery whereas they are not ready for surgery according to the anaesthetists' assessment.

The ASA classification of the nurse was compared to that of the anaesthetist using cross tabulation. The Kappa statistic was estimated. As the time to complete the health assessment had a skewed distribution, a log transformation was applied, resulting in a normal distribution. To quantify whether the health assessment times differed significantly between nurses and anaesthetists, the paired samples *t*-test was used to obtain the mean difference with 95% CI of 'log assessment time'.

Results

Patient characteristics

The characteristics of the 4540 study patients are shown in Table 1. Significant comorbidity (ASA 3 and 4) was present in 247 patients (5.5%). Table 2 shows the characteristics of study patients and the eligible patients that did not participate, stratified by ASA classification. There were no differences in the prevalence of drug use, previous surgeries, cardiac or pulmonary disease between the participating and non-participating subjects. As a result of the large number of patients, the differences in body mass index and mean blood pressure were statistically significant but not clinically relevant. These results

Table 1 Patient characteristics ($N = 4540$). Numbers are absolute values (%).

Gender: male		2147 (47.3)
Mean age (SD); year		48.2 (16.2)
Surgery:	General surgery	849 (18.7)
	Ear-Nose-Throat/Dental surgery	815 (17.9)
	Gynaecology/Obstetrics	577 (13.2)
	Orthopaedic surgery	563 (12.4)
	Eye surgery	492 (10.8)
	Plastic surgery	439 (9.7)
	Urology	304 (6.7)
	Neurosurgery	261 (5.7)
	Vascular surgery	128 (2.8)
	Other (Radiotherapy, Nephrology)	112 (2.5)
Patients with significant comorbidity (ASA 3 or 4)*		247 (5.5)

ASA = American Society of Anesthesiologists physical condition rating scale. *Available for 4495 patients (99%).

Table 2 Comparison of study patients ($N = 4495$) and non-study patients ($N = 3295$) stratified by ASA classification. Numbers are percentages (dichotomous variables) or means (SD) (continuous variables).

	ASA 1 and 2 (*N* = 7168)			ASA 3 and 4 (*N* = 622)		
	Study patients *N* = 4248	Other patients *N* = 2920	OR or MD (95% CI)	Study patients *N* = 247	Other patients *N* = 375	OR or MD (95% CI)
History						
Use of any drug	61	66	0.8 (0.7–0.9)*	98	97	1.2 (0.4–3.4)
Previous surgeries	86	86	1.0 (0.8–1.1)	94	94	1.1 (0.5–2.2)
Cardiac disease	8	8	0.9 (0.6–1.2)	38	41	0.9 (0.6–1.2)
Current cardiac complaints	3	4	0.9 (0.7–1.2)	23	21	1.1 (0.7–1.8)
Vascular disease	7	8	0.9 (0.8–1.1)	36	30	1.3 (0.9–1.8)
Cerebrovascular accident	4	4	0.9 (0.7–1.2)	14	18	0.7 (0.5–1.1)
On treatment for hypertension	14	16	0.9 (0.8–1.0)	42	43	1.0 (0.7–1.4)
Asthma or COPD	14	14	0.8 (0.6–1.2)	33	38	0.8 (0.6–1.2)
Current respiratory complaints	8	8	0.9 (0.8–1.1)	28	26	1.1 (0.7–1.6)
Diabetes	5	6	0.8 (0.7–1.0)	28	22	1.3 (0.9–1.9)
Physical examination						
Cardiac murmurs	4	4	1.0 (0.7–1.2)	16	15	1.1 (0.7–1.7)
BMI; kg.m^{-2}	26.0 (12.6)	26.2 (18.3)	0.2 (−0.5–0.9)†	28.6 (11.3)	26.5 (6.5)	2.1 (0.6–3.5)†*
BP; mmHg	100 (12.8)	100 (13.8)	0.7 (0.0–1.4)†*	102 (14.6)	102 (16.2)	0.1 (−2.5–2.5)†

ASA, American Society of Anesthesiologists physical condition rating scale; OR, Odds ratio; MD, Mean Difference; BMI, Body Mass Index; Mean BP = ((2 × diastolic pressure) + systolic pressure))/3, †, Mean difference; *, Significant at $p < 0.05$.

indicate that the participating patients were a representative sample of all eligible patients.

Primary outcome

The primary outcome was available for 4319 (95.1%) of the 4540 study patients. The characteristics of the 221 patients (4.9%) with missing outcome did not differ from the rest. Overall, 317 patients (7.3%) were considered 'not ready' for surgery (Table 3). Anaesthetists and nurses classified 3757 of the 4319 patients similarly, yielding an overall accuracy of 87% (95% CI: 86–88%). In 54 cases (1.3%; 95% CI: 1.0–1.6%) the nurse classified the patient as 'ready', whereas the anaesthetist did not, yielding a sensitivity of 83%. Table 4 shows the characteristics of the 54 patients in whom the nurse possibly missed significant comorbidity. In 43 cases (79%), the misclassifications were cardiovascular in origin.

Of the 508 patients classified by nurses as 'not ready' but by anaesthetists as 'ready', in 162 (32%) the nurse believed to have heard a cardiac murmur or abnormal lung sounds. The anaesthetist confirmed these auscultation abnormalities in 29 cases, but labelled them as 'not pathological'. In 150 cases (30%), the nurse classified the patient as 'not ready' because history revealed possible angina, possible congestive heart failure, or asthma, and in 75 patients (15%) because of an elevated blood pressure. In 41 patients (8%) the nurse expected a difficult airway. In the remaining 80 patients (16%) it was unclear why the nurse had classified them as 'not ready'.

Table 3 Association of the classification 'ready for surgery' and 'not ready, needs work-up, by the nurses vs. the classification by the anaesthetists (reference standard). Numbers are patient numbers and percentages of the total number (4319) between parentheses.

		Anaesthetists		
		Not ready (T+)	Ready (T−)	Total
Nurses	Not ready (T+)	263 (6.1)	508 (11.8)	771 (17.9)
	Ready (T−)	54 (1.3)	3494 (80.9)	3548 (82.1)
	Total	317 (7.3)	4002 (92.7)	4319 (100)

T+, 'Test' positive; T−, 'Test' negative; Sensitivity, 83% (263/317), 95% CI: 79–87%; Specificity, 87% (3494/4002); 95% CI: 86–88%. Positive predictive value = 34% (263/771), 95% CI: 31–38%. Negative predictive value = 98% (3494/3548), 95% CI: 98–99%.

Secondary outcomes

In total, 3361 patients (75%) were similarly classified as ASA 1, 2 or 3 by nurses and anaesthetists (Table 5). The Kappa statistic was 0.55 (95% CI: 0.53–0.57). Nurses classified 247 (5.5%) patients as ASA 1, where in fact they were ASA 2 or 3. Table 6 shows the time required by the nurses and anaesthetists to complete the health assessments. On average, nurses required 1.85 times the time used by anaesthetists (95% CI: 1.80–1.90).

Discussion

The results of the OPEN study suggest that trained nurses can discriminate patients who are ready for surgery from

Table 4 Patients classified by the nurse as 'ready' but considered 'not ready' by the anaesthetist ($N = 54$).

Reason	*N* (%)	Description of cases
Cardiac	24 (44.4)	Cardiovascular comorbidity present in 12 (hypertension and ⁄ or history of cerebrovascular accident).
Angina	4	In 2 angina was suspected; referred to cardiologist. Other 2 already known to have angina (NYHA 2 and 3). For both additional information requested from cardiologist.
Congestive heart failure	3	All dyspnoeic with crepitations on lung auscultation (not detected by nurse); 1 morbid obesity (BMI 42) and on treatment for hypertension. All referred to cardiologist
Newly detected murmur	8	In 5 murmurs were not detected by nurse. All 8 referred for echocardiography: 3 mild to moderate aortic stenosis (peak gradients 16, 20 and 45 mmHg), 1 moderate mitral and aortic regurgitation and in 4 no significant valvular abnormalities found. In none was further work-up considered necessary before surgery.
History of cardiac disease	9	In all additional information from cardiologist requested; in none was further work-up considered necessary before surgery.
Elevated blood pressure	16 (29.6)	In 6 a borderline-normal blood pressure (< 160 ⁄ 100 mmHg) was present during the nurses' health assessment. Referred to family physician for further evaluation ⁄ treatment: 8. Already on treatment for hypertension: 3. Actions undertaken not specified: 5.
Cardiac and endocrinological	2 (3.6)	One had history of severe systolic and diastolic left ventricular disfunction, with hypertension, diabetes and peripheral vascular disease, other had stable angina (NYHA 1), hypertension, renal insufficiency with hyperkalaemia and diabetes.
Cardiac and pulmonary	1 (1.8)	Oesophageal resection. History: myocardial infarction, CABG 2 months before, severe asthma, very low exercise tolerance
Pulmonary	3 (5.5)	1: exacerbation of asthma and obesity (BMI 43); referred to family physician. 1: severe asthma with low exercise tolerance after lung resection 50 years before; pulmonologist consulted. 1: severe emphysema; pulmonologist consulted.
Endocrinologic ⁄ coagulation	4 (7.3)	Suspected hypothyroidism: 2 (laboratory values: normal thyroid function). In 1 diabetes newly diagnosed; referred to family physician. Suspected coagulation disorder: 1 (prolonged bleeding after teeth extractions): no laboratory abnormalities
Other (airway)	4 (7.2)	In 3 surgery was postponed for 6 weeks because of severe common cold (1), acute tonsillitis (1) or gingivitis (1) after a dental procedure. The fourth had history of angio-oedema of the tongue and throat after use of (unspecified) drugs.

NYHA, New York Heart Association; BMI, Body Mass Index in $kg.m^{-2}$; OPE, Outpatient Preoperative Evaluation; CABG, Coronary Artery Bypass Grafting.

Table 5 ASA classification by the anaesthetists and by the nurses of the 4495 study patients (99%) with data on outcome. Numbers are patient numbers (%).

		Anaesthetists				
		ASA 1	ASA 2	ASA 3	ASA 4	Total
Nurses	ASA 1	1617 (36.0)	244 (5.4)	3 (0.1)	0 (0.0)	1864 (41.5)
	ASA 2	603 (13.4)	1629 (36.2)	126 (2.8)	0 (0.0)	2358 (52.5)
	ASA 3	7 (0.2)	148 (3.3)	115 (2.6)	3 (0.1)	273 (6.1)
	Total	2227 (49.5)	2021 (45.0)	244 (5.4)	3 (0.1)	4495 (100)

ASA, American Society of Anesthesiologists physical condition rating scale; Kappa, 0.55 (95% CI 0.53–0.57).

those who need further assessment and work-up. The overall accuracy of the nurses was 87%, with a sensitivity of 83% and a specificity of 87%, but 54 patients (1.3%) were incorrectly classified by the nurse as 'ready for surgery' while in fact they were not.

Anaesthetists and nurses classified 87% of all patients similarly; the nurses correctly classified 81% as 'ready' and 6% as 'not ready'. This implies that in fact 81% of surgical patients do not require health assessment by an anaesthetist. In these patients, nurses can substitute the health assessment part of OPE. Obviously, the 6% of patients classified as 'not ready' by both the nurse and the anaesthetist still needs to be assessed further by the anaesthetist. The prior assessment by the nurse and the label 'not ready' will likely trigger the anaesthetist to carefully assess this subgroup of patients, which may improve the quality of peri-operative care.

In total, 13% of the patients were diagnosed incorrectly by the nurse, either as 'ready' when in fact they were not (1.3%), or as 'not ready' when the anaesthetist considered them 'ready' (11.7%). The main effect of the latter group is a negative effect on the efficiency of OPE, since these patients will still need to be referred to the anaesthetist for

Table 6 Time required in minutes by the anaesthetists and by the nurses to complete the health assessments during OPE, stratified by ASA classification.

Patients		Median (25th; 75th)	Geometric mean	Ratio (95% CI)
All	Nurse	9 (7; 12)	8.7	1.85 (1.80–1.90)
	Anaesthetist	5 (3; 8)	4.7	
ASA 1	Nurse	7 (5; 10)	7.3	1.99 (1.91–2.07)
	Anaesthetist	4 (2; 6)	3.7	
ASA 2	Nurse	10 (7; 14)	10.1	1.81 (1.74–1.89)
	Anaesthetist	6 (4; 9)	5.6	
ASA 3 or 4	Nurse	13 (9; 19)	13.3	1.55 (1.37–1.76)
	Anaesthetist	9 (5; 14)	8.6	

ASA, American Society of Anesthesiologists physical condition rating scale; 25th; 75th, 25th and 75th percentiles; Geometric mean, Exp (mean log time); Ratio, ratio of geometric means.

further assessment. This negative effect is also reflected in the low positive predictive value of 34% of the nurses' assessment. To prevent unnecessary postponement of surgery in these patients, an anaesthetist should be available for further evaluation directly after the nurse has finished the initial assessment. It seems likely that additional education and increasing experience in distinguishing abnormal from normal heart and breath sounds, will reduce the number of patients incorrectly diagnosed by the nurse as 'not ready for surgery' (accounting for 32% of this type of misclassification in the present study).

In 1.3% of the patients, the anaesthetist considered additional work-up necessary while they were classified as 'ready for surgery' by the nurse (Table 4). Seven of the 24 patients with cardiac disease had relevant comorbidity (two with newly detected angina, three with congestive heart failure and two with moderate valvular heart disease). Regarding the 16 patients with high blood pressure only, it should be noted that six patients had a borderline normal blood pressure during the nurses' assessment. Furthermore, the beneficial effect of postponing surgery to treat high blood pressure remains unknown. Of the remaining 14 patients, six patients had relevant comorbidity as well (two cardiac and endocrine, one cardiac and pulmonary and three pulmonary). Hence, 13 of the 54 patients had significant comorbidity that was not detected by the nurse. If these patients were not further assessed by the anaesthetist at the OPE clinic, the surgery would possibly have been cancelled just before entering the operating room, leading to an increase of 0.3% (13/4319) in late surgery cancellations.

On the other hand, Table 4 also shows that the relevant conditions that were not detected mainly were due to incorrect interpretation of heart and breath sounds. It is likely that additional nurse education in a continuous feedback driven program would further improve efficacy and reduce the number of patients incorrectly diagnosed as 'ready for surgery'. Moreover, further education together with increasing experience would also decrease the time required by the nurses to complete the health assessment.

If there is a shortage of anaesthetists, hospitals may consider implementing a nurse based OPE clinic. The partial substitution of anaesthetists by nurses may be a solution to the shortage of anaesthetists, but can only be cost-effective if the assignment of nurses is less costly than that of anaesthetists. In the present study, nurses needed 1.85 times longer than anaesthetists to perform the assessment (Table 6). Thus, at the current level of training, about two nurses are needed to substitute the workload of one anaesthetist to perform routine preoperative health assessment. In the Netherlands, the salary costs of trained nurses are about 30% of those of anaesthetists. However, a difference in working hours between nurses and physicians as well as other issues (e.g. costs of 0.3% extra late cancellations, training costs and costs of ongoing education) need to be evaluated in a formal cost-effectiveness analysis, which was beyond the scope of the present diagnostic study, but will be part of future research.

The anaesthetists' assessment was the reference standard for the assessment by the nurse. This standard cannot be considered as a true gold standard, as anaesthetists may also miss certain conditions. However, in current perioperative practice the anaesthetist is the final 'diagnostic instrument' to determine whether a patient is suitable for surgery or not. Recent methodological guidelines recommend that the best available procedure in practice should be used as reference in diagnostic accuracy studies [12–14]. Accordingly, we used the anaesthetist's judgment as the reference standard.

We explicitly did not choose a randomised, longitudinal design to address our study question: each patient first visited the nurse and subsequently the anaesthetist. It has been advocated that the most efficient and valid design for a diagnostic accuracy question is the non-randomised cross-sectional design in which each patient is measured by the test under study ('the nurse') and subsequently by the reference test ('the anaesthetist') [12–14]. Nevertheless, one could argue that patients should have visited anaesthetists and nurses in a random sequence as patients may reveal more relevant information in the second interview or the patient may have told everything already during the first interview and is reluctant to do it all over again. However, we hypothesised that if our study would show that nurses can substitute the health assessment by anaesthetists, the sequence as studied would always become routine practice and not vice versa.

The possible substitution of anaesthetists by specially trained nurses in the OPE process was discussed in one previous study [7]. This study used a design similar to ours, but was non-blinded and had a smaller sample size (668 outpatients). It revealed a sensitivity of 46% (where we found 83%) and a specificity of 68% (87% in our study). The authors considered these figures satisfactory, although it was acknowledged that the sensitivity was low. Substitution of preregistration house officers by nurses to overcome a shortage of physicians was also described earlier [10]. Recently, in a randomised trial the competence of three nurses in health assessment before surgery was compared to the competence of preregistration house officers [8]. Neither group performed particularly well, but it was concluded that nurses were no worse than preregistration house officers in assessing patients pre-operatively. In primary care settings, a comparison of nurses and specialised physicians has been described more often. Differences in cost-effectiveness between family physicians and nurses were not demonstrated [20–22].

We conclude that by allowing nurses to serve as a diagnostic filter to identify the subgroup of patients who may safely undergo surgery without further diagnostic workup or optimisation, anaesthetists can focus on patients who require additional attention before surgery. Thus, nurses can substitute for the health assessment by anaesthetists in a majority of patients, provided that the anaesthetist is available to perform additional assessment when patients are categorised as requiring further work-up. Most patients who were incorrectly labelled as 'ready for surgery' seemed not to have been more at risk if anaesthesia was initiated based on the nurses' classification. To increase the benefits of the involvement of nurses in pre-operative health assessment, a continuous re-education of nurses seems warranted.

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