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Preoperative prediction of potentially preventable morbidity after fast-track hip and knee arthroplasty: a detailed descriptive cohort study

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ABSTRACT

Objectives: Construction of a simple preoperative risk score for patients in high risk of potentially preventable 'medical' complications. Secondary objectives were to construct simple preoperative risk scores for 'severe medical', 'surgical' and 'total' potentially preventable complications.

Design: Prospective observational study.

Setting: Elective primary unilateral total hip and knee arthroplasty with prospectively collected preoperative patient characteristics; similar standardised fast-track protocols; evaluation of complications through discharge and medical records; and complete 90 days follow-up through nationwide databases.

Participants: 8373 consecutive unselected total hip arthroplasty (THA) and knee arthroplasty from January 2010 to November 2012.

Results: There were 557 procedures (6.4%) followed by potentially preventable complications resulting in hospitalisation >4 days or readmission. Of 22 preoperative characteristics, 7 were associated with 379 (4.2%) potentially preventable 'medical' complications. Patients with ≥2 of the following, age ≥80 years, anticoagulant therapy, pulmonary disease, pharmacologically treated psychiatric disorder, anaemia and walking aids, composed 19.1% of the procedures; 55.7% constituted potentially preventable 'medical' complications that were mainly falls, mobilisation issues, pneumonias and cardiac arrhythmias. The number needed to be treated for a hypothetical intervention leading to 25% reduction in potentially preventable 'medical' complications was 34. THA, use of walking aids and cardiac disease were associated with 189 (2.2%) 'surgical' complications, but no clinically relevant preoperative prediction was possible.

Conclusions: Preoperative identification of patients at high risk of preventable 'medical', but not 'surgical', complications is statistically possible. However, clinical relevance is limited. Future risk indices should differ between 'medical' and 'surgical' complications, and also consider 'preventability' of these.

Trial registration number: NCT01515670.

Strengths and limitations of this study

- A large cohort of patients with total hip arthroplasty and total knee arthroplasty with standardised fast-track protocols and prospective recording on preoperative morbidity.
- Detailed follow-up on postoperative complications through discharge records.
- Differentiation between 'medical' and 'surgical' complications.
- Evaluation of preventability of complications is subjective.
- Validation in other types of fast-track surgery is needed.

INTRODUCTION

As with any multifactorial problem, prediction of postoperative morbidity in surgical patients is difficult. However, the potential benefit of being able to identify and ultimately allocate high-risk patients to an appropriate level of care is vast. For example, more than 80% of postoperative deaths have been found to occur in a subgroup of high-risk patients with a likely higher number of non-fatal complications.[1]

Several risk stratification tools have been developed to help clinicians decide whether preoperative optimisation of organ function, changes in perioperative care or postponement of surgery may be indicated. Starting with the American Society of Anesthesiologists' Physical Status score (ASA),[2] the other scores, such as the Physiological and Operative Severity Score for enUmeration of Mortality and Morbidity (POSSUM),[3] the Surgical APGAR score[4] and the Charlson Comorbidity Index,[5] have also been found useful for predicting postoperative morbidity, and may be supplemented by cardiopulmonary exercise tests.[6 7]

Recently, internet-based risk calculators published by the American College of Surgeons' National Surgical Quality Improvement Program, have been developed for a variety of procedures and outcomes.[8 9] However, the extent to which these are used in clinical practice is uncertain, and the ideal preoperative risk stratification tool has yet to be found.[10] Furthermore, if used to guide postoperative care, such a tool should be developed in patients receiving up-to-date evidence-based care and must consider the pathophysiological mechanisms leading to the outcome of interest, thus enabling rational inteventions.[11]

In this context, it must be considered that many risk indices were developed at a time when perioperative care was different from today. Thus, the introduction of enhanced recovery programmes or the so-called 'fast-track' surgery[12] has led to changes in surgical, anaesthetic and rehabilitative practices, which have improved postoperative recovery, reduced morbidity and consequently reduced length of hospital stay (LOS) without increasing readmissions.[13] However, whether traditional perioperative risk assessment is transferable to the concept of fast-track surgery remains to be answered.[11] In this context, recent studies in fast-track total hip arthroplasty (THA) and total knee arthroplasty (TKA) have found that traditional risk factors, such as age,[14 15] obesity,[16] cardiopulmonary disease,[15] smoking or alcohol use,[16 17] and type 2 diabetes,[18] may have less influence on LOS and postoperative morbidity than has been estimated in previous studies with conventional care. In addition, the types of postoperative morbidity in fast-track surgery may also differ from previous reports on conventional care. Thus, low incidences of delirium,[19] venous thromboembolic events[20] as well as myocardial infarctions and overall mortality have been found in fast-track THA and TKA.[21] The combination of different risk profiles and incidences of postoperative complications in fast-track surgery may influence the accuracy of previously established risk indices, thereby calling for procedure-specific studies with implemented fast-track methodology.[22] Finally, assessment of 'medical' versus 'surgical' complications rather than traditional assessment of 'all cause' morbidity is necessary to define interventional strategies.[11]

The present study attempted to develop a simple numerical score to identify patients at high risk of specific potentially preventable postoperative 'medical' and 'surgical' complications, which is based on previous works on patient-related risk factors and postoperative morbidity in fast-track THA and TKA.[15 17 23–25]

METHODS

The study population was based on a previously published cohort from the Lundbeck Foundation Centre for Fast-Track Hip and Knee Replacement database (LCDB) from January 2010 to November 2012, thus ensuring a high degree of details regarding postoperative morbidity resulting in LOS >4 and 90 days readmissions.[15 18 25] The cut-off of >4 days was chosen based on median LOS being 3 days in 2010.[15] Eight large Danish Regional/University hospitals with dedicated arthroplasty departments performing >400 procedures/year are currently reporting to the LCDB, which is a prospective registry on preoperative comorbidity registered on ClinicalTrials.gov (ID: NCT01515670). None of the previous investigations based on this cohort have attempted to summarise relevant risk factors into a risk score regarding potentially preventable complications.

All departments have similar fast-track protocols, including spinal anaesthesia, opioid-sparing multimodal analgesia, early mobilisation and with planned discharge to own home.[26] The data in the LCDB are cross-referenced with the Danish National Patient Registry for information on the index surgery and 90 days follow-up on readmissions and mortality. The Danish National Patient Registry collects data on all admissions in Danish with a data completeness of >99%.[27] Information on preoperative use of continuous anticoagulants, pharmacological antidiabetic and psychiatric treatment is acquired from the Danish National Database on Reimbursed Prescriptions which registers any prescription receiving reimbursement dispensed outside hospitals (the usual practice in the government-funded Danish healthcare system).[28]

LOS was counted as the number of postoperative nights in hospital, including transferrals to other departments. Any case of LOS >4 days or readmissions within 90 days were investigated using discharge records to identify the primary cause. This was done by the primary author (CCJ) who consulted the senior author (HK) in case of doubts. If information in the discharge record was deemed insufficient, a review of the entire medical record was performed by CCJ and HK that was followed by discussion until agreement with relation to surgery. In case of death, the complete medical records/autopsy reports and death certificates were obtained. Only surgery-related readmissions resulting in overnight stay in hospital were considered relevant, that is, uncomplicated urinary tract infections, syncope and acute worsening of chronic obstructive pulmonary disease (COPD) without antibiotic treatment after postoperative day 30 and other admissions obviously unrelated to index surgery (evaluation of newly discovered cancer, eye surgery, cholecystitis, allergic reactions unrelated to postoperative treatment, etc.) were excluded. Causes of LOS >4 days and readmissions were subsequently divided into 'surgical' (related directly to the surgical technique and prosthesis components) and 'medical' (related to the surgical procedure or pre-existing conditions but potentially reversible by non-surgical intervention) based on previous work.[15]

Following initial screening for relation to surgery, an evaluation on the potential preventability of the reasons for LOS>4 days and readmissions was conducted by both CCJ and HK. This evaluation focused on whether an

intervention either preoperatively or during the first 2–3 postoperative days could potentially have prevented LOS >4 days or readmission. Most 'medical' conditions were included a priori if occurring during primary admission or resulting in readmission ≤30 days after surgery, while some conditions required further evaluation of medical records followed by discussion until mutual agreement was reached by both reviewers. A few conditions, that is, urinary retention (n:12) and uncomplicated urinary tract infection (n:18), were excluded due to lack of preoperative information on voiding difficulties, postoperative intermittent catheterisations, and chronic urinary tract infection. Furthermore, postoperative ileus was excluded due to its rarity (n:7), and multifactorial pathogenesis (table 1) 'surgical' readmissions were included ≤90 days after surgery as these often present later than 'medical' complications (table 1). Finally, of the included complications, we classified the following as severe: confirmed cardiac complications, severe hypotension unresponsive to fluids, cerebral stroke or

Table 1 Included and excluded types of complications

'Medical'	'Surgical'
Included a priori as potentially preventable if resulting in LOS ≥4 or 30 days readmission*:	Included a priori as potentially preventable if resulting in LOS >4 or 30 days readmission:
Myocardial infarction	Hip dislocation not caused by falling
Unstable angina	Knee manipulation under anaesthesia
Heart failure	Wound infections with antibiotic treatment
Cardiac arrhythmia (LOS >4 days or after discharge but ≥7 days after surgery)	Superficial infection with wound incision
	Deep infection with removal of prosthetic components
Cerebral stroke/transient cerebral ischaemia	
Delirium/psychosis	
Venous thromboembolic events	
Pneumonia/acute worsening of chronic obstructive disease	
Sepsis without wound infection	
Unexplained infection	
Falls	
Renal infection with increase in creatinine and fluid/diuretic treatment only	
Fluid/electrolyte derangement treated with fluids only	
Renal infection resulting in dialysis	
Mobilisation issues preventing fulfilling functional discharge criteria within 4 days or need of inhospital rehabilitation after discharge	
Opioid-related side effects	
Included for further evaluation on preventability:	Included for further evaluation on preventability:
Unexplained hypotension/hypertension	
Unexplained fainting or dizziness	
Unexplained dyspnoea	
Constipation unrelated to opioids	
Complications related to existing comorbidity†	
Any condition not fitting other descriptions	
Excluded a priori as being potentially preventable by perioperative intervention:	Excluded a priori as being potentially preventable by perioperative intervention:
No recorded morbidity (LOS >4 days only)	Postanaesthetic complications
Postoperative ileus	Periprosthetic fracture without recorded trauma
Diarrhoea	Revision due to prosthetic malfunction
Disproved venous thromboembolic event	Other planned reoperations
Disproved myocardial infarction	Systemic arterial thrombosis/pseudoaneurism
Disproved wound infection	
Social considerations	
Excluded a priori due to lack of information necessary for qualified evaluation:	Excluded a priori due to lack of information necessary for qualified evaluation:
Gastric ulcer/gastritis	Major postoperative haematoma/swelling
Urinary retention	Major intraoperative bleeding
Uncomplicated urinary tract infection	Minor wound bleeding
Pain	

*Anaemia requiring blood transfusion despite no recorded major intraoperative bleed.
†For example, difficulties with vitamin K or antihyperglycaemic treatment, management of sleep apnoea.
LOS, length of stay.

transient cerebral ischaemia, delirium or psychosis, confirmed venous thromboembolic events, pneumonia, worsening of COPD, unexplained dyspnoea with severe hypoxaemia, sepsis, falls, renal affection requiring dialysis, prosthetic infections with surgical interventions, hip dislocations and knee manipulation under anaesthesia (MUA). Only the first potentially preventable 'medical' or 'surgical' complication was included for analysis; however, a subsequent severe complication was included if the first complication did not qualify as such.

Objectives

Construction of a simple risk score for patients at high risk of potentially preventable 'medical' and 'severe medical' complications leading to LOS >4 days or readmission. Secondary outcomes were to construct simple risk scores for 'surgical' and 'total' potentially preventable complications.

Statistics

Data distribution was analysed using the Kolmogorov-Smirnov test. Results for non-parametric data are given as medians with IQRs. Risk prediction models for 'total', 'medical', 'severe' medical and 'surgical' complications were constructed using univariate analysis followed by stepwise multiple logistic regression. A significance level ≤0.10 was chosen for univariate analysis to reduce the risk of excluding variables with significant associations after adjustments.[29] The included variables were: gender, age ≥75, ≥80 and ≥85 years (cut-offs based on previous work,[15] with only the most significant age dichotomisations included in the multiple regression), living alone, smoking, alcohol use of >24 g/day, use of walking aids, body mass index (BMI) >30, surgical procedure (THA vs TKA), hypertension, hypercholesterolaemia, antihyperglycaemic treatment for diabetes, pharmacologically treated psychiatric disorder,[25] cardiac disease, pulmonary disease, previous cerebral stroke, previous venous thromboembolic event, use of anticoagulants (vitamin K antagonists, dabigatranetexilate or rivaroxaban). Place of surgery was included in the multiple logistic regression analysis as a random effect. A significance level of 0.05 was chosen for multiple regression models. Two-way interactions between significant variables were added and tested. Receiver operating characteristic of the final model was pictured and area under the curve (AUC) was calculated. To assess whether accuracy could be improved, we used three different weightings for combining the included variables into a total score: one using the ORs, one using a baseline value of 1 for each variable, and one using a value of 1 in case of an OR <1.90 and 2 if ≥1.90. The final analysis was done on the largest possible data set, but with minor variations due to missing data for specific preoperative characteristics (table 2).

For the risk score, we calculated the positive (PPV) and negative predictive values (NPV), and the number needed to treat (NNT) with different weighting and chose combinations of the included variables to find a clinically relevant cut-off for 'high-risk' patients. We also calculated how many complications would have been

Table 2 Preoperative characteristics

THA	4565 (52.2)
TKA	4172 (47.8)
Age/years median (IQR)	68 (67–75)
<50	524 (6.0)
51–60	1465 (16.8)
61–65	1384 (15.8)
66–70	1717 (19.7)
71–75	1546 (17,7)
76–80	1191 (13.6)
81–85	650 (7.4)
>85	260 (3.0)
Females	5031 (57.8)
BMI median (IQR)	27.7 (24.8–31.2)
<18.5	69 (0.8)
18.5–24.9	2284 (26.2)
25.0–29.9	3475 (39.9)
30–34.9	1960 (22.5)
35–39.9	685 (7.9)
>40	237 (2.7)
Missing	27 (0.3)
BMI ≥30	2882 (33.0)
Missing	27 (0.3)
Anaemia	1107 (12.8)
Missing	77 (0.9)
Walking aids	2126 (24.8)
Missing	177 (2.0)
Living alone	2954 (33.8)
With others	5783 (66.2)
Missing	0 (0.0)
Smoking	1325 (15.3)
Missing	90 (1.0)
Alcohol >24 g/day	599 (6.9)
Missing	73 (0.8)
Hypertension	4585 (52.8)
Missing	55 (0.6)
Hypercholesterolaemia	2572 (29.4)
Missing	80 (0.9)
Diabetes with antihyperglycaemic treatment	861 (9.9)
Missing	35 (0.4)
Anticoagulant treatment*	445 (5.1)
Missing	0 (0.0)
Cardiac disease	1083 (12.4)
Missing	128 (1.5)
Pulmonary disease	658 (7.6)
Missing	73 (0.8)
PsD with pharmacological treatment	975 (11.2)
Missing	393 (4.5)
Previous stroke	528 (6.1)
Missing	129 (1.5)
Previous venous thromboembolic event	469 (5.5)
Missing	152 (1.7)

Parentheses are per cent unless otherwise specified.
*Vitamin K antagonists or new oral anticoagulants.
BMI, body mass index; PsD, psychiatric disorder; THA, total hip arthroplasty; TKA, total knee arthroplasty.

avoided in our study cohort if applying hypothetical interventions reducing complications by 50%, 33% and 25%. When testing differences in occurrences of specific complications, we used a significance level of 0.001 to account for multiple comparisons. Analysis was done using SPSS V.20 ((IBM Corporation, Armonk, New York, USA) and SAS V.9.3 (SAS institute inc, Cary, North Carolina, USA))

RESULTS

A total of 8804 procedures in 8288 patients were eligible for analysis. We excluded 67 (0.8%) procedures in patients coming from nursing homes or other institutions, as these composed a very small and potentially different patient population. Of the remaining 8737 procedures, 1362 (15.6%) were followed by complications leading to either LOS >4 days or readmissions, but only 568 complications (6.4% of all procedures, range per year: 5.8–7.0%) were potentially preventable). Of 379 (4.2%) 'medical' complications of which 213 (2.3%) were 'severe', 258 (3.0%) resulted in LOS >4 days and 121 (1.4%) resulted in readmissions. Correspondingly, of 189 (2.2%) 'surgical' complications of which 177 (2.0%) were 'severe', 13 (0.1%) and 176 (2.0%) resulted in LOS >4 days and readmissions, respectively (see online table supplementary data 1 for details).

Primary objectives: 'medical' and 'severe medical' complications

The final regression model for 'medical' complications included the following seven characteristics: age ≥80 years, hypertension, use of anticoagulants, pulmonary disease, pharmacologically treated psychiatric disorder, anaemia and use of walking aids (see online supplementary data 2 table S1 for results of logistic regression). The AUC was between 0.75 and 0.76 regardless of weighting, and with an estimated risk of developing a 'medical' complication leading to either LOS >4 days or readmission of 67% with seven preoperative predictors. No patient had seven predictors and only 6 (0.07%) patients had six. All combinations of predictors had a NPV of ≥0.96, but the highest PPV was only 0.32 (≥5 predictors); these patients were only 0.9% of the population (table 3). Assigning a value of 1 for each predictor and using a cut-off of ≥3 selected 14.2% of patients with a 12.9% complication rate and encompassing 45.0% of all 'medical' complications. If excluding hypertension, which was present in 52.4% of the population, from the relevant medical predictors (medical predictors excluding hypertension, MPEH) and using a cut-off of ≥2, 19.1% (range13.9–21.2% per department) of patients would be risk patients (table 3 figure 1) encompassing 55.7% (range 50.0–65.7% per department) of 'medical' complications. The NNT with a hypothetical intervention reducing 'medical' complications by 25% in patients with ≥2 MPEH was 34, and 46 (14.0%) complications would have been avoided in the cohort. No improvement in predictive ability was found when assigning a value of 2 to predictors with an OR of ≥1.9 (maximum of 12), regardless of excluding hypertension (table 3).

When analysing the cases of 'severe medical' complications, we found that anaemia and hypertension no longer qualified as predictors (see online supplementary data 2 table S2 for results of logistic regression). AUC was 0.75 and the estimated risk was 45.1% with all five predictors. No patient had all predictors and only 0.3% had 4. Using a cut-off of ≥2 of these five predictors would result in 14.9% risk patients, who contributed 48.4% of all severe complications. However, if using ≥2 MPEH as cut-off, 54.2% of the severe complications occurred in risk patients (table 3 and figure 1), resulting in a NNT of 59 and avoiding 26 (14.0%) complications.

Overall, the most frequent complications in patients with ≥2 MPEH were: anaemia, mobilisation issues, pulmonary, cardiac, renal/fluid related and falls. In contrast, there were few cases of opioid-related morbidity, delirium, thromboembolic events and severe renal complications (figure 2A,B). Of 'severe' complications, the significantly more were pulmonary, cardiac and due to falls in patients with ≥2 MPEH versus patients with <2 MPEH (p<0.0001; figure 3). The majority of pulmonary and cardiac complications were pneumonias (n: 23) and arrhythmias (n:18) occurring in 1.5% and 1.2% of patients, respectively, with ≥2 MPEH.

Secondary objectives: 'surgical' and 'total' complications

For 'surgical' complications, the final regression model included three characteristics: joint of surgery, use of walking aids and cardiac disease. As only three characteristics, one of which was the surgical procedure, were associated with 'surgical' morbidity no clinically relevant prediction based on preoperative risk factors was possible. However, there were more hip dislocations in patients with THA (3.6% vs 1.5%, p<0.001) and no MUAs in patients with TKA (0.0% vs 0.9%, p=0.006) with ≥2 MPEH. For details on analysis on 'surgical' complications see supplementary data 3. Multiple logistic regression analysis on 'total' complications found a significant association with the following preoperative characteristics: age ≥75 years, hypertension, cardiac disease, pulmonary disease, pharmacologically treated psychiatric disorder, anaemia and use of walking aids. The risk of developing a complication leading to either LOS >4 days or readmission was 49.8% if all seven predictors were present prior to surgery; however, no patient had all seven predictors and only 36 (0.5%) patients had six. For details of analysis on 'total' complications see supplementary data 4.

Mortality

Sixteen (0.2%) deaths occurred within 30 days after surgery. Of these, one was unrelated to surgery (cancer related) and one was in a patient with some missing preoperative data (pulmonary embolism). Of the 14

Table 3 Predictive ability of combinations of significant predictors

Outcome	Characteristic (%)	Events (%)		Percentage of events	Percentage correct	Sensitivity	Specificity	PPV	NPV	NNT 50	NNT 33	NNT 25	AE 50	AE 33	AE 25
		Yes	No												
'Medical' complications n: 327	Age ≥80 years (12.3)	118 (11.9)	872	36.1	86.5	36.09	88.67	0.12	0.97	17	25	34	59	39	30
	Walking aids (24.2)	187 (9.6)	1753	57.2	76.4	57.19	77.22	0.10	0.98	21	31	41	94	62	47
	Hypertension (52.4)	221 (5.3)	3982	67.6	49.0	67.58	48.25	0.05	0.97	38	57	76	111	74	55
	Anticoagulants (5.0)	42 (10.5)	357	12.8	92.0	12.84	95.36	0.11	0.96	19	29	38	21	14	11
	Anaemia (12.4)	94 (9.4)	904	28.7	85.8	28.75	88.25	0.09	0.97	21	32	42	47	31	24
	Psychological disorder (11.6)	78 (8.4)	851	23.9	86.3	23.85	88.94	0.08	0.96	24	36	48	39	26	20
	Pulmonary disease (7.4)	46 (7.7)	551	14.1	89.6	14.07	92.84	0.08	0.96	26	39	52	23	15	12
	≥3 predictors (14.3)	147 (12.9)	996	45.0	85.3	44.95	87.05	0.13	0.97	16	23	31	74	49	37
	≥4 predictors (4.3)	68 (19.8)	275	20.8	93.3	20.80	96.43	0.20	0.97	10	15	20	34	23	17
	≥5 predictors (0.9)	24 (32.4)	50	7.3	95.6	7.34	99.35	0.32	0.96	6	9	12	12	8	6
	≥4 MP2 (18.1)	174 (12.0)	1276	53.2	82.2	53.21	83.42	0.12	0.98	17	25	33	87	58	44
	≥5 MP2 (12.8)	139 (13.6)	886	42.5	86.6	42.51	88.48	0.14	0.97	15	22	29	70	46	35
	≥2 MPEH (19.1)	182 (11.9)	1348	55.7	81.4	55.66	82.50	0.12	0.98	17	25	34	91	61	46
	≥3 MPEH2 (5.6)	83 (18.5)	366	55.7	92.4	25.38	95.14	0.18	0.97	11	16	22	42	28	21
'Severe medical' complications n:213	Age ≥80 years (12.3)	70 (7.0)	928	36.8	87.1	36.84	88.32	0.07	0.98	29	43	57	35	23	18
	Walking aids (24.2)	108 (5.5)	1861	56.8	76.1	56.84	76.57	0.05	0.99	36	55	73	54	36	27
	Anticoagulants (4.9)	27 (6.7)	378	14.2	93.3	14.21	95.24	0.07	0.98	30	45	60	14	9	7
	Psychological disorder (11.6)	48 (5.1)	895	25.3	87.2	25.26	88.73	0.05	0.98	39	59	79	24	16	12
	Pulmonary disease (7.5)	31 (5.11)	577	16.3	90.9	16.32	92.73	0.05	0.98	39	59	78	16	10	8
	≥2 predictors (14.9)	92 (7.6)	1122	48.4	85.0	48.42	85.87	0.08	0.99	26	40	53	46	31	23
	≥3 predictors (3.1)	31 (12.4)	218	16.3	95.4	16.32	97.26	0.12	0.98	16	24	32	16	10	8
	≥4 predictors (0.3)	6 (23.1)	20	3.2	97.5	3.16	99.75	0.23	0.98	9	13	17	3	2	2
	≥3 MP (14.3)	83 (7.3)	1060	43.7	85.5	44.62	86.47	0.07	0.99	28	41	55	42	28	21
	≥4 MP2 (18.1)	98 (7.0)	1352	51.6	82.1	52.69	82.74	0.07	0.99	30	44	59	49	33	25
	≥2 MPEH (19.1)	103 (6.7)	1427	54.2	81.2	55.38	81.79	0.07	0.99	30	45	59	52	34	26

Number of included patients is 8021 for 'medical' complications and 8132 for 'severe medical' complications due to 8.1% and 6.9% with missing data on relevant predictors.
AE 25, avoided events in the cohort with 25% event reduction; AE 30, avoided events in the cohort with 30% event reduction; AE 50, avoided events in the cohort with 50% event reduction; MP2, 'medical' predictors with two points if OR ≥1.9; MPEH, medical predictors excluding hypertension; MPEH2, 'medical' predictors excluding hypertension and two points if OR ≥1.9; NNT 25, number needed to treat if there is a 25% event reduction; NNT 30, number needed to treat if there is a 30% event reduction; NNT 50, number needed to treat if there is a 50% event reduction; NPN, negative predictive value; PPV, positive predictive value.

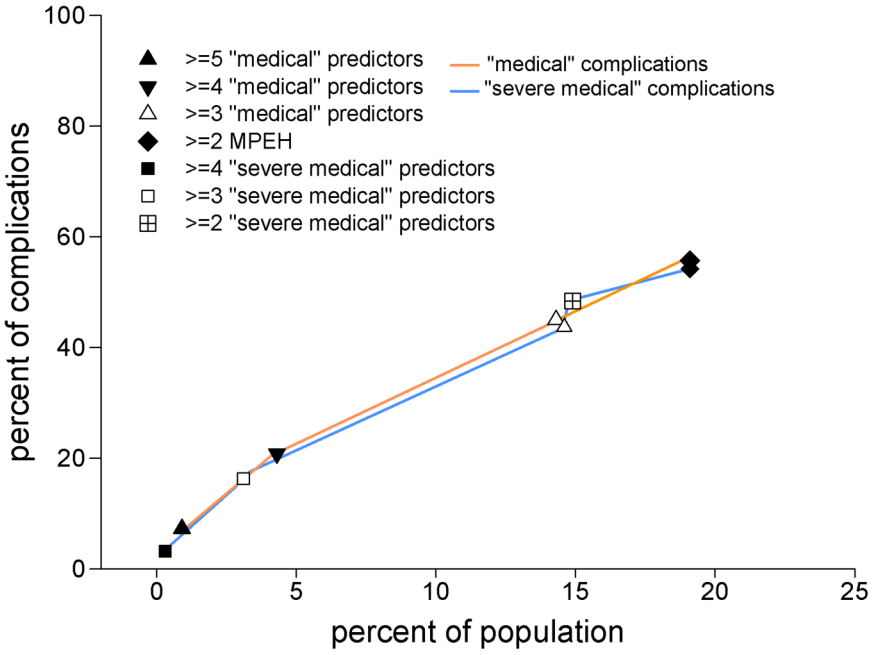

Figure 1 Relationship between per cent of complications and percentage of population for combinations of predictors and weightings. MPEH, medical predictors excluding hypertension.

potentially (0.1%) surgery-related deaths, 11 (0.7%) were in patients with ≥2 MPEH versus 3 (0.04%) with <2 MPEH (p<0.001).

DISCUSSION

Predicting which patients will develop complications after surgery is difficult, but focus on improving postoperative outcomes through better perioperative care is increasing.[13 30 31] Our study in fast-track THA and TKA found that although identification of high-risk patients for potentially preventable 'medical' complications based on preoperative risk factors is statistically possible, the clinical relevance is limited by diverse types of complications and a high NNT. Furthermore, we found that predictors for 'surgical' and 'medical' complications were not the same, thus demonstrating the importance of distinguishing between these, especially considering that neither statistically nor clinically relevant preoperative prediction was possible regarding 'surgical' complications. Finally, our study demonstrated the necessity of considering preventability of complications, as this was the case in only about 40% of patients with LOS >4 days or readmissions. Similar results have been reported in mixed patients, where the fraction of preventable unplanned readmissions is about 20–30%.[32 33]

Apart from the obstacles of few potentially 'preventable' complications and different predictors of potentially preventable 'medical' and 'surgical' complications, there is the problem of defining suitable strategies for

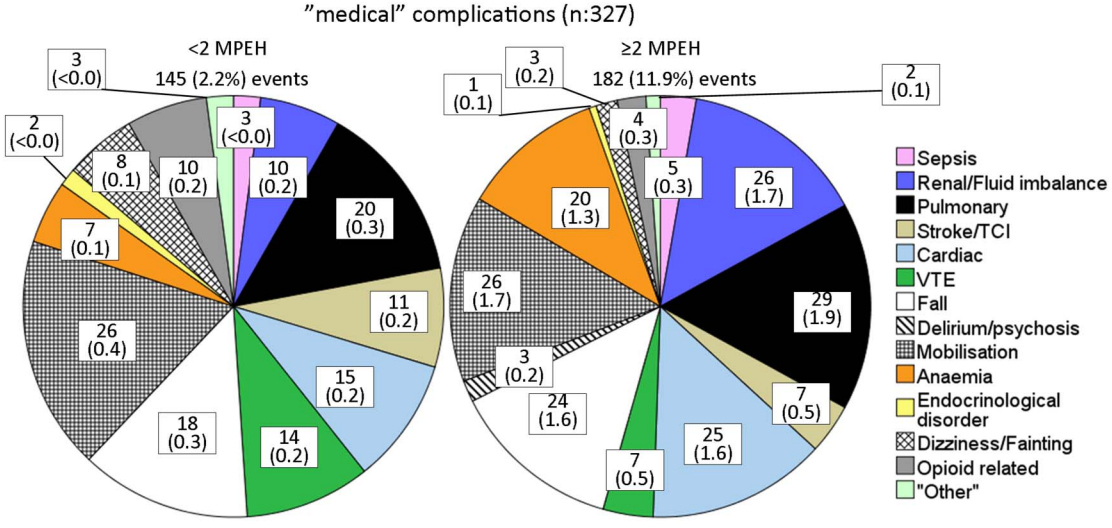

Figure 2 Occurrence and fraction of specific types of 'medical' complications in patients with <2 'medical' predictors excluding hypertension (MPEH) n: 6491 vs ≥2 MPEH n: 1530. TCI, transient cerebral ischaemia; VTE, venous thromboembolic event.

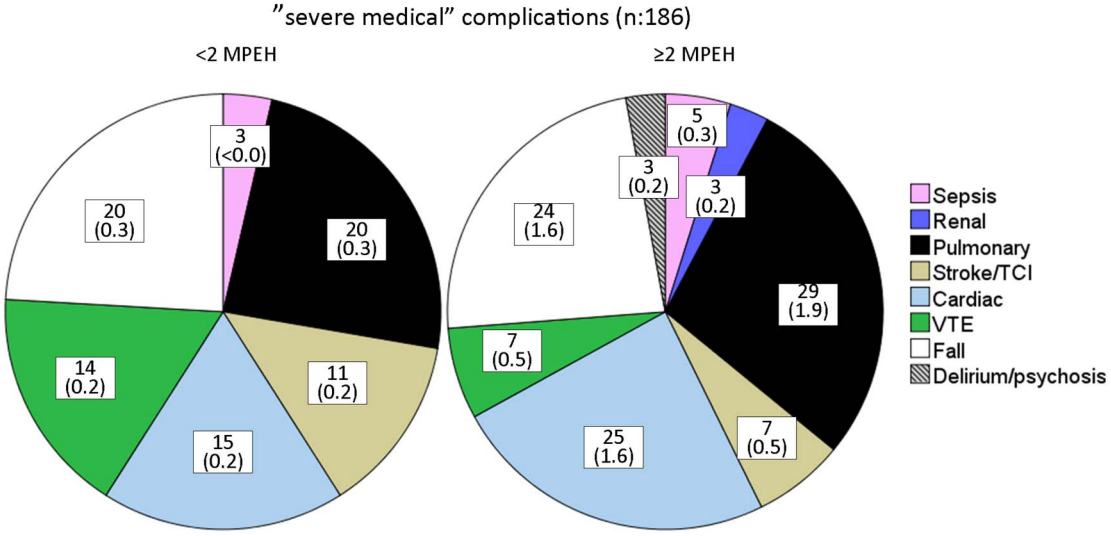

Figure 3 Occurrence and fraction of specific types of 'severe medical' complications in patients with <2 'medical' predictors excluding hypertension (MPEH) n: 6491 vs ≥2 MPEH n: 1530. TCI, transient cerebral ischaemia; VTE, venous thromboembolic event.

reducing these. Thus, 'medical' complications may be reduced by further optimisation of the fast-track methodology, while 'surgical' complications would be dependent on surgical expertise.[11]

In our opinion, the most clinically relevant cut-off for defining patients at high risk of potentially preventable 'medical' complications was ≥2 MPEH. This encompassed about 20% of all patients, with minor variation between departments, and these accounted for more than half of the 'medical' complications. Interventional studies targeting patients with ≥2 MPEH could focus on falls, mobilisation issues, pneumonia and cardiac arrhythmia as these occurred most frequently. Unfortunately, a significant reduction of such diverse postoperative 'medical' complications is likely to require a multimodal interventional strategy, including correction of preoperative anaemia and ward rounds by anaesthesiologists or geriatricians. Such attempts have shown promising results both in orthopaedic and in other types of surgery.[34–36] However, designing the required randomised trials within a standardised fast-track protocol will be challenging, especially considering the large number of patients needed.

Prediction of 'surgical' complications was all but impossible in the present study, but it is interesting that no cases of MUA were present in the patients with ≥2 MPEH, supporting our previous findings of MUA being associated with younger age and independence from walking aids.[37] Finally, how to reduce the number of hip dislocations in patients with ≥2 MPEH deserves further study.

Previous studies of smaller cohorts contributing to the present study[15 17 18 20] and in other study cohorts[14 16 19 38] have found a reduced importance of conventional risk factors and decreased postoperative morbidity in fast-track THA and TKA compared with studies with conventional perioperative care. This was confirmed in the present study where smoking, alcohol use, diabetes requiring antihyperglycaemic treatment and a BMI of >30 were not associated with postoperative complications, and even when using ≥2 MPEH to define patients at risk of 'medical' complications, the high NNT limited the clinical relevance. However, whether this also applies to other types of fast-track surgery and to other patient populations remains unknown. Thus, characterisation of the high-risk patients and postoperative morbidity in other fast-track surgical procedures and populations is needed. This may be especially important regarding obesity, where it could be argued that our BMI cut-off should have been placed at 35 or beyond.[39]

Our study is subject to some limitations. As it was observational, we can only provide associations. However, the intention was to define a clinically relevant group of high-risk patients, and not to demonstrate causality between preoperative characteristics and specific complications. Furthermore, evaluation of complications is subjective and the inclusion of three or more reviewers to solve potential disagreements by majority vote may have been preferable. It could also be argued that we should have used an existing index for evaluation of postoperative complications. Unfortunately, existing indices are subject to limitations, for example, the Dindo-Clavien index focuses on the most severe complications, with no distinction between 'medical' or 'surgical' morbidity and without consideration of preoperative risk factors.[40] The Comprehensive Complication Index expresses all complications as a single score,[41] but does not consider the order of occurrence or whether the initial complications led to subsequent complications. The Postoperative Morbidity Survey[42] may be inadequate for recording morbidity in fast-track orthopaedic patients. A weakness from evaluating patient records is that unrecorded information may have led to misclassification regarding the preventability

of the complication and whether it was 'medical' or 'surgical'. Nonetheless, this approach is likely to be superior to using diagnostic codes, and has been proposed as the best way of determining preventability of readmissions.[43] Finally, the results should ideally be confirmed in a different cohort having fast-track THA and TKA to confirm the validity and predictive ability of the identified risk factors.

The strengths of our study include a detailed analysis of postoperative morbidity distinguishing between what came first; whether 'medical' or 'surgical', it made use of prospectively recorded data on patient characteristics, and had a well-described standardised fast-track setup[26] with consecutive unselected patients and nationwide databases with complete follow-up.[27 28]

In conclusion, this study demonstrates the importance of distinguishing between 'medical' and 'surgical' morbidity when investigating the role of preoperative risk factors. Additionally, the predictive value of the six relevant predictors for developing potentially preventable 'medical' complications was limited and no clinically relevant prediction of 'surgical' complications was possible.

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Contributors CCJ contributed to the idea and study design, collection, evaluation and analysis of data, writing and revising the primary draft. MAP contributed to the refinement of the statistical methods, statistical analysis and revision of the primary draft. HK contributed to the idea and study design, evaluation and analysis of data, and revision of the primary draft.

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Competing interests HK is a board member of the Health Care initiative Biomet Rapid Recovery.

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