Impact of Trainee Participation on Inguinal Hernia Repair Outcome

A Study Based on the Swedish Hernia Register

Hans Lederhuber, MD, PhD,[*]✉ *Bengt Hanßke, MD, PhD,*[*] *and Ursula Dahlstrand, MD, PhD*[†]

Objective: The aim of this study was to investigate whether differences in postoperative outcome exist between open inguinal hernia repairs performed by surgical trainees and those performed by specialist surgeons.

Summary of Background Data: Inguinal hernia repair is the prototype educational surgical procedure. The impact of trainee participation on postoperative outcome is still controversial and despite earlier studies no reliable hernia-specific data exist.

Methods: The study cohort was based on the Swedish Hernia Register and consisted of 61,161 cases of male patients aged 18 years and older with open anterior mesh repair of a primary inguinal hernia between January 1, 2002, and December 31, 2014. The study cohort was selected to represent the typical trainee procedure in Sweden. Primary outcome measures were reoperation due to hernia recurrence and postoperative 30-day complications.

Results: Procedures with longer operating times were at a higher risk for reoperation when performed by supervised trainees [57 to 72 minutes: hazard ratio (HR) 1.55, 99% confidence interval (99% CI) 1.05–2.27] or unsupervised trainees (57 to 72 minutes: HR 1.60, 99% CI 1.18–2.17; >72 minutes: HR 1.72, 99% CI 1.25–2.37). The same was true for specialist and trainee-assisted specialists with operating times <43 minutes (HR 1.63, 99% CI 1.25–2.13; HR 1.58, 99% CI 1.09–2.28). Postoperative 30-day complications were generally associated with longer operating times and occurred at all levels of experience.

Conclusion: Trainee participation in open inguinal repair in combination with longer operating time is a risk factor associated with higher reoperation rates. This calls for a more structured supervision of trainees in an assumedly basic procedure.

Keywords: inguinal hernia repair, postoperative outcome, recurrence, surgical education, trainee

(*Ann Surg* 2021;274:e62–e69)

Inguinal hernia repair is a part of the surgical syllabus in most countries. It is among the most frequently performed surgical procedures worldwide and general surgeons are expected to perform it adequately early in their careers.[1] Despite an observed increase in early exposure to laparoendoscopic hernia surgery, in many countries, open hernia procedures still account for the bulk of training procedures during early surgical education,[2] as they combine an appropriate technical challenge with a less steep learning curve and low mortality rates.

From the [*]Department of General Surgery, Torsby Hospital, Region Värmland County Council, Värmland, Sweden; and †Department of Clinical Sciences, Intervention and Technology (CLINTEC), Karolinska Institutet, and Centre for Digestive Diseases, Karolinska University Hospital, Stockholm, Sweden.
✉ha.lederhuber@mailbox.org.

This study was supported with grants from Region Värmland County Council and the Swedish Society of Innovative Surgical Technology (SIKT).
The authors have no conflicts of interest.

ISSN: 0003-4932/19/27401-0e62
DOI: 10.1097/SLA.0000000000003497

Although surgical training must be provided for trainees, training procedures cannot be allowed to carry a systematically higher risk for complications. Involvement of trainees in hernia surgery, as in other surgical procedures, has therefore been discussed extensively. Register data show overall recurrence related reoperation rates of less than 5%,[3,4] but it has been demonstrated that the estimated number of unreported cases might be much higher.[5] Data on frequency of postoperative complications differ widely, depending on the definition of complications.

It has previously been reported that trainee involvement in surgical procedures is associated with longer operating times (OTs).[6–12] Many studies suggest that trainee participation in surgical procedures can be an independent risk factor for minor postoperative complications, but that it in general does not seem to negatively affect major complication rate or long-term patient outcome.[11,13–20] Large-scale, hernia-specific data on the subject are missing and the existing studies are either due to design not able to deliver robust statements about recurrence or they are highly heterogeneous due to the nature of registration and evaluation of the underlying data.

The aim of this study on routinely and prospectively collected national register data was to investigate whether differences in postoperative outcome between inguinal hernia repairs performed by surgical trainees and those performed by specialist surgeons exist. The study cohort was selected with the intention to represent the typical trainee procedure in Sweden.

METHODS

The RECORD statement,[21] extended from the STROBE statement for observational studies using routinely collected health data, was applied to the present study. The work was based on data from the Swedish Hernia Register (SHR), a national register of inguinal hernia repairs performed by the 93 participating surgical units (data from 2016). The register covers almost 100% of inguinal hernia repairs performed in Sweden in patients older than 15 years.[22]

Study Design

Data extracted from SHR included registered cases between January 1, 2002, and December 31, 2014. Inclusion and exclusion criteria were set to define a study group with procedures that could be considered suitable for trainees to manage. The type of procedure studied was open anterior mesh repair (ie, Lichtenstein repair and its variations) with suture fixation for primary inguinal (nonfemoral) hernia. Patients with bilateral repair were registered as 2 cases (ie, 1 entry for each side). Male patients aged 18 years and older were included. Females were excluded, as preperitoneal mesh repair is recommended for them.[23] In order to prevent bias introduced by cases considered particularly prone for complications, only patients classified ASA 1 to ASA 3 as described by the American Society of Anesthesiologists were included. For the same reason, patients with BMI below 16.0 kg/m^2 or exceeding 35.0 kg/m^2 were excluded.

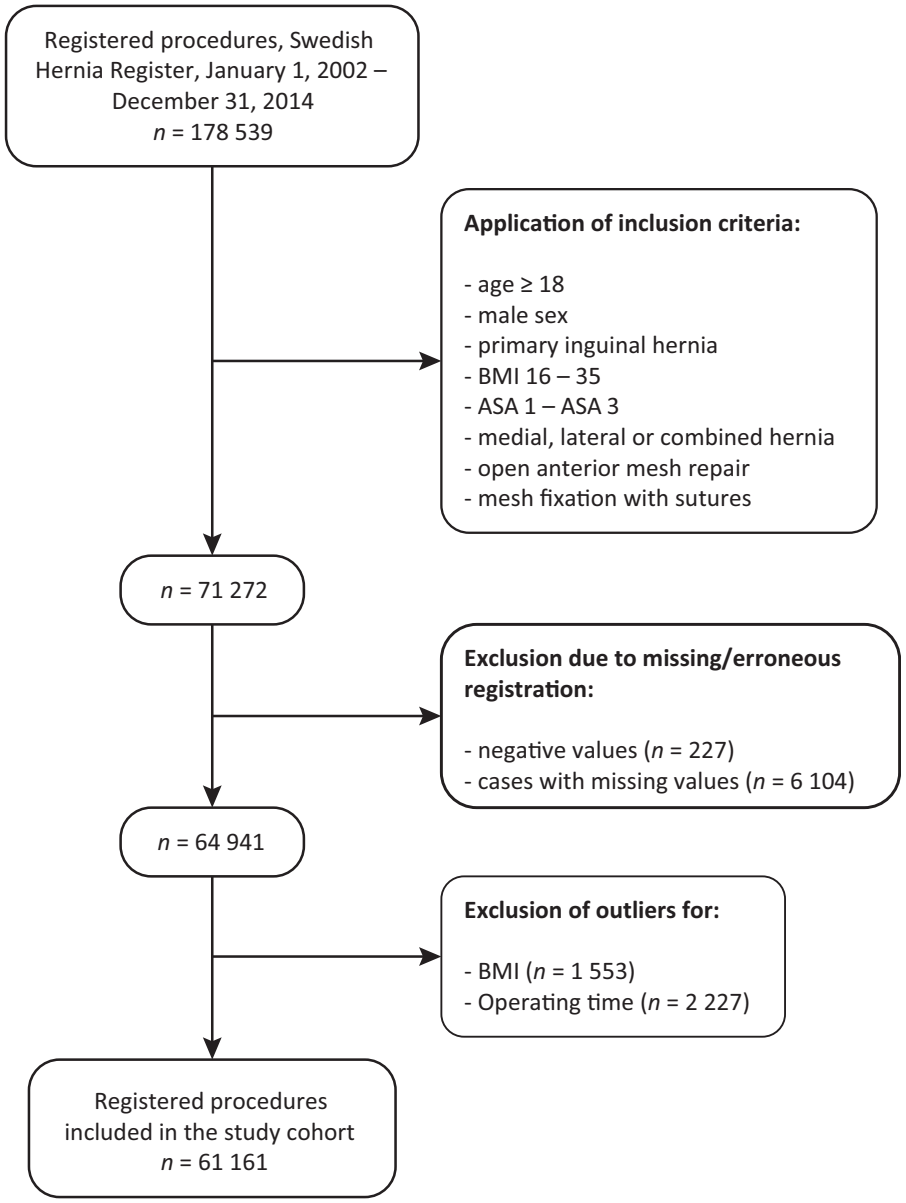


FIGURE 1. Flowchart showing cohort assembly.

Primary outcome measures were *reoperation due to hernia recurrence* and *postoperative complications within 30 days*. Thirty-day complications were limited to *hematoma, surgical site infection*, and *severe postoperative pain*.

Variables analyzed for association with the outcomes were *surgical experience* (as defined below); *age* [in years as a continuous variable (only for the outcome 30-day complications)]; *ASA-class* as specified by the American Society of Anesthesiologists (ASA 1; ASA 2; ASA 3), *hernia type* (direct/medial inguinal hernia; indirect/lateral inguinal hernia; combined hernia), *hernia aperture size* (<1.5 cm; ≥1.5 cm <3.0 cm; ≥3.0 cm), *mesh fixation* [nonabsorbable suture (eg, Prolene, Surgipro); slowly absorbable suture (eg, PDS, Maxon); absorbable suture (eg, Dexon, Vicryl)], *operating time* (grouped in quartiles: ≤43 minutes; >43 minutes ≤57 minutes; >57 minutes ≤72 minutes; >72 minutes), *BMI* (underweight/normal weight; pre-obesity/class I obesity), and *surgical priority* (acute procedure; elective procedure). For the outcome *reoperation due to recurrence* the variable *30-day complication* (hematoma; surgical site infection; severe postoperative pain) was also included. Clavien-Dindo classification was first introduced into the SHR in 2015 and is therefore not reported.

For the variable *surgical experience*, the participation of surgical trainees in the hernia repair was subgrouped as follows: specialists only (S); specialist as primary surgeon with trainee as assisting surgeon (ST); trainee as primary surgeon with specialist as assisting surgeon = supervised trainee (TS) and; unsupervised trainee(s) (T). The Swedish surgical syllabus is skill-controlled and requires a minimum of 5 years full-time work in order to apply for board certification; adjacent subspecialty training is not formally part of surgical training. Advanced trainees may, after approval from their supervising consultants, be allowed to perform inguinal hernia repair autonomously.

TABLE 1. Baseline Characteristics in 61,161 Males With Open Anterior Mesh Repair for Primary Inguinal Hernia Between January 1, 2002, and December 31, 2014

Characteristic	Total (N = 61,161)	S (n = 26,680)	ST (n = 11,481)	TS (n = 8,866)	T (n = 14,134)
Patient baseline					
BMI [kg/m^2; median]	24.8	24.8	24.8	24.9	24.8
IQR [kg/m^2]	(23.2–26.6)	(23.2–26.6)	(23.2–26.7)	(23.3–26.8)	(23.2–26.5)
Age [y; median]	63	62	63	63	63
IQR [y]	(52–71)	(51–71)	(53–72)	(53–72)	(53–73)
ASA-class					
ASA 1	34,978 (57.2)	15,897 (59.6)	6435 (56.0)	4686 (52.9)	7960 (56.3)
ASA 2	21,120 (34.5)	8817 (33.0)	3917 (34.1)	3341 (37.7)	5045 (35.7)
ASA 3	5063 (8.3)	1966 (7.4)	1129 (9.8)	839 (9.5)	1129 (8.0)
Hernia repair baseline					
Surgical priority					
Acute	1746 (2.9)	806 (3.0)	340 (3.0)	233 (2.6)	367 (2.6)
Elective	59,415 (97.1)	25,874 (97.0)	11,141 (97.0)	8633 (97.4)	13,767 (97.4)
Type of hernia					
Medial	22,016 (36.0)	9547 (35.8)	4067 (35.4)	3145 (35.5)	5257 (37.2)
Lateral	33,432 (54.7)	14,585 (54.7)	6327 (55.1)	4905 (55.3)	7615 (53.9)
Combined	5713 (9.3)	2548 (9.6)	1087 (9.5)	816 (9.2)	1262 (8.9)
Hernia size					
<1.5 cm	8787 (14.4)	3525 (13.2)	1381 (12.0)	1409 (15.9)	2472 (17.5)
≥1.5 cm <3.0 cm	30,363 (49.6)	12,632 (47.3)	5600 (48.8)	4772 (53.8)	7359 (52.1)
≥3.0 cm	22 011 (36.0)	10,523 (39.4)	4500 (39.2)	2685 (30.3)	4303 (30.4)
Suture material					
Absorbable	1111 (1.8)	590 (2.2)	237 (2.1)	141 (1.6)	143 (1.0)
Slowly absorbable	1783 (2.9)	706 (2.6)	265 (2.3)	425 (4.8)	387 (2.7)
Nonabsorbable	58,267 (95.3)	25,384 (95.1)	10,979 (95.6)	8300 (93.6)	13,604 (96.3)
Operating time					
Median, min	57	48	55	70	68
IQR [min]	(43–72)	(35–60)	(43–70)	(57–85)	(55–83)
≤43 min	15,550 (25.4)	10,735 (40.2)	2928 (25.5)	628 (7.1)	1259 (8.9)
>43 min ≤ 57 min	15,455 (25.3)	7595 (28.5)	3267 (28.5)	1659 (18.7)	2934 (20.8)
>57 min ≤ 72 min	14,962 (24.5)	5 296 (19.9)	2880 (25.1)	2613 (29.5)	4173 (29.5)
>72 min	15,194 (24.8)	3054 (11.4)	2406 (21.0)	3966 (44.7)	5768 (40.8)
Outpatient surgery	49,987 (81.7)	22,117 (82.9)	9188 (80.0)	6922 (78.1)	11,760 (83.2)
Complication baseline					
Reoperation due to recurrence	1508 (2.5)	635 (2.4)	269 (2.3)	221 (2.5)	383 (2.7)
Time to recurrence [y; median]	7.8	8.1	7.2	7.2	8.0
IQR [y]	(6.0–10.0)	(6.2–10.5)	(5.8–8.9)	(5.8–9.5)	(6.1–10.2)
30-d complications					
Hematoma	1752 (2.9)	752 (2.8)	307 (2.7)	279 (3.1)	414 (2.9)
Surgical site infection	671 (1.1)	260 (1.0)	130 (1.1)	113 (1.3)	168 (1.2)
Severe postoperative pain	380 (0.6)	161 (0.6)	60 (0.5)	52 (0.6)	107 (0.8)

Follow-up from index operation until December 31, 2016.

Percentages may not add up 100 due to rounding. If not stated otherwise, numbers shown represent n (% total).

ASA indicates American Society of Anesthesiologists; BMI, body mass index; cm, centimeter; IQR, interquartile range; min, minutes; S, specialist(s) only; ST, trainee-assisted specialist; T, unsupervised trainee(s); TS, supervised trainee.

Statistical Analysis

Only cases with complete and conclusive recording (eg, no negative OT) of all assessed variables were included. All cases with outliers (defined as < Q1 - 1.5*IQR and > Q3 + 1.5*IQR; *Q1* = 1st quartile; *Q3* = 3rd quartile, *IQR* = interquartile range) for the variables body mass index (BMI) or OT were excluded.

A Bonferroni-corrected column proportions *z*-test was used to analyze differences between groups. Multinomial logistic regression analysis was used to compute adjusted odds ratios (ORs) for postoperative 30-day complications (with 99% confidence intervals, CI) and multivariable Cox proportional hazard regression was performed to compute adjusted hazard ratios (HRs) for reoperation due to recurrence after index surgery (with 99% CI). Age was excluded from hazard regression analysis, as reoperation rates may decrease with age due to factors not related to the incidence of hernia recurrence (eg, considered too old for operation). *Surgical experience* was highly correlated with *operating time*; in order to avoid multicollinearity, these 2 variables were not included in the same regression analysis. To explore whether surgical experience is an independent risk factor for recurrence and complication beyond its influence on OT, stratification was achieved by coding a combinatory variable of surgical experience and OT *surgical experience & operating time* (with 4 x 4 variable parameters). Exit date for Cox regression was the date of reoperation, date of death, or December 31, 2016. Follow-up time was thus at least 2 years and maximum 15 years. Reported *P* values are 2-sided and, unless reported otherwise, *P* values <0.01 were considered statistically significant. Data were analyzed using SPSS Statistics version 25 (IBM Corporation, Armonk, NY).

The study was fully approved by the regional ethical review board in Uppsala, Sweden (Dnr. 2015/206).

RESULTS

Between January 1, 2002, and December 31, 2014, a total of 178,539 cases were recorded in the SHR. After application of the inclusion criteria to the database, exclusion of missing and obvious

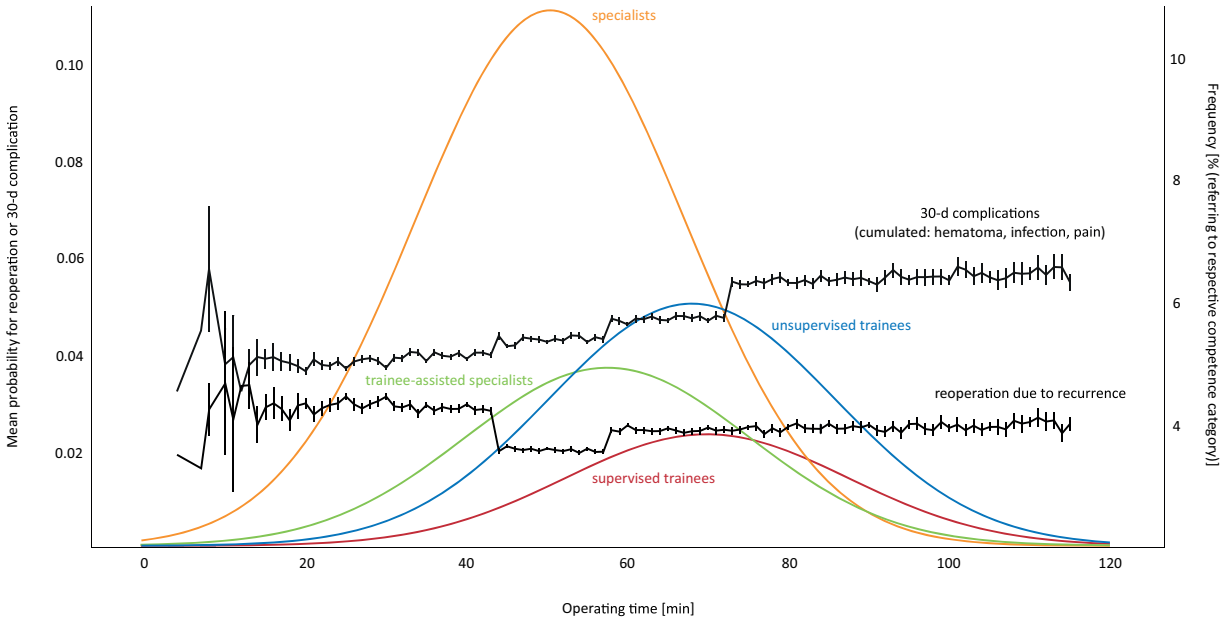


FIGURE 2. Relation between operating time and mean probability for reoperation, mean probability for 30-day postoperative complications, and formal level of experience. Error bars indicate 95% confidence interval. Frequencies per competence category of procedures performed for any given operating time by the respective competence are displayed as standard distribution curves.

erroneous data and exclusion of outliers for BMI and OT, a total of 61,161 patient cases were included into the study cohort (see Fig. 1). Median follow-up time was 7.8 years (IQR 6.0 to 10.0). Bonferroni-corrected column proportion *z*-test comparison showed differences between unsupervised trainees' and specialists' median OTs, reoperation rates, and surgical site infections ($P < 0.05$). Baseline data are summarized in Table 1.

Correlations between OT and reoperation due to recurrence and summarized 30-day complications, respectively, are shown in Fig. 2. Mean probability for reoperation was lower for OTs between 43 and 57 minutes compared with OTs less than 43 minutes or over 57 minutes. Mean probability for 30-day complications increased linearly with longer operation time. These findings were applied to the proposed model by including the combinatory variable *surgical experience & operating time.* The results of the multivariable hazard regression regarding risk for reoperation due to recurrence are summarized in Table 2 and Fig. 3. While Table 2 presents those of the above-mentioned outcome associated variables that are independent risk factors for reoperation, Fig. 3 illustrates separately for the variable *surgical experience & operating time* that unsupervised trainees and specialist surgeons were risk factors for reoperation depending on either long or particular short OTs. Results from the multivariable logistic regression of risk factors for 30-day complications are summarized in Table 3 and Fig. 3. Table 3 summarizes the independent risk factors for reoperation due to recurrence except for the variable *surgical experience & operating time*, which is illustrated in Fig. 3. It shows that 30-day complications are correlated with OTs longer than 72 minutes and that unsupervised trainees as well as specialists and assisted specialists are risk factors for such complications.

DISCUSSION

The aim of the presented study was to use a highly standardized cohort to investigate whether the postoperative outcome after open inguinal hernia mesh repair differs depending on whether it is performed by a surgical trainee or a specialist surgeon. The study showed that patients were at a higher risk for reoperation due to recurrence when either unsupervised trainees or supervised trainees performed the procedure and exceeded certain OTs. The same was true for specialist surgeons with particularly short OTs. Postoperative 30-day complications were in general associated with longer OTs but occurred equally often at all levels of experience.

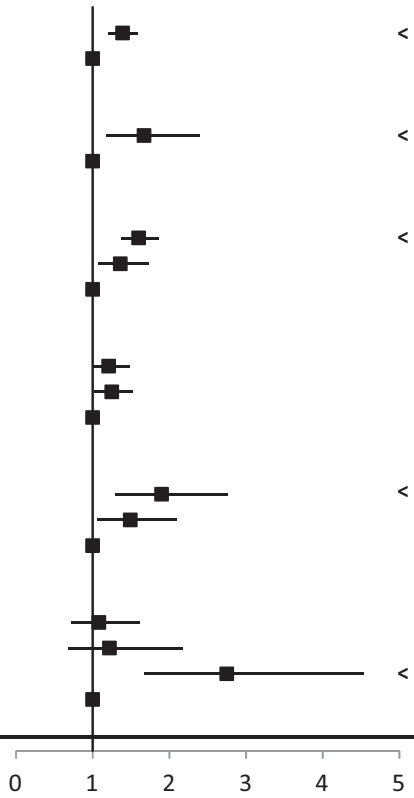
Impact of trainee participation on outcome in hernia surgery is not easily assessed, as data interpretation is sensitive and possibly controversial. In contrast to others,[13,16] the presented study cannot unequivocally report that trainee participation does not affect postoperative outcomes. Only few of the previous studies show higher complication rates for trainees at all: Wilkiemeyer et al[14] proposed that junior trainees were associated with higher recurrence rates than senior ones; similar findings were presented by Robson et al.[18] The results in the present study differ from theirs in that unsupervised trainees in particular were associated with higher reoperation rates when certain OTs were exceeded.

Short OT has in previous, nonhernia studies been associated with favorable outcome, whereas longer OT led to increased morbidity.[24,25] This linear correlation between OT and outcome was, at least for hernia surgery, previously questioned by van der Linden et al[26] in a study based on the SHR. It illustrated the complex and not necessarily linear correlation between OT and outcome. The interdependence of surgical experience, OT, and outcome was touched upon but not discussed in depth in any of the studies.

Stepwise regression models of the presented data could show reciprocal effects of OT and surgical experience, both being effect modifier *and* confounder. This is why a variable combining both was used in the final regression model. On the basis of the data from this tailored cohort, the authors suggest avoiding an oversimplification of the correlation between OT, surgical experience, and outcome. Longer OT must not necessarily be associated with worse outcome; longer OT might however in the case of a trainee be a sign of disparity between surgical challenge and individual surgical experience.

TABLE 2. Risk Factors for Reoperation due to Recurrence in 61,161 Males With Open Anterior Mesh Repair for Primary Inguinal Hernia Between January 1, 2002 and December 31, 2014

Characteristic	Re-operation rate [n/No. at risk (%)]	Hazard ratio [99% CI]	*p*
BMI			
Pre-obesity/class I obesity	845/28 836 (2.9)	1.39 (1.21 – 1.59)	**< 0.001**
Normal-/underweight (Ref.)	663/32 325 (2.1)	*1.00 (Ref.)*	
Surgical priority			
Acute	55/1 746 (3.2)	1.67 (1.17 – 2.39)	**< 0.001**
Elective (Ref.)	*1 453/59 415 (2.4)*	*1.00 (Ref.)*	
Type of hernia			
Medial	728/22 016 (3.3)	1.60 (1.37 – 1.86)	**< 0.001**
Combined	152/5 713 (2.7)	1.36 (1.07 – 1.73)	**0.001**
Lateral (Ref.)	*628/33 432 (1.9)*	*1.00 (Ref.)*	
Hernia Size			
≥ 1.5 cm < 3.0 cm	712/30 363 (2.3)	1.21 (1.00 – 1.48)	0.012
> 3.0 cm	635/22 011 (2.9)	1.25 (1.02 – 1.52)	**0.004**
< 1.5 cm (Ref.)	*161/8 787 (1.8)*	*1.00 (Ref.)*	
Suture material			
Absorbable	49/1 111 (4.4)	1.90 (1.30 – 2.76)	**< 0.001**
Slowly-absorbable	61/1 783 (3.4)	1.49 (1.06 – 2.09)	**0.002**
Non-absorbable (Ref.)	*1 398/58 267 (2.4)*	*1.00 (Ref.)*	
30-day complication			
Hematoma	43/1 752 (2.5)	1.08 (0.72 – 1.61)	0.630
Surgical site infection	20/671 (3.0)	1.22 (0.68 – 2.17)	0.387
Severe postoperative pain	27/380 (7.1)	2.75 (1.67 – 4.54)	**< 0.001**
No complication (Ref.)	*1 371/56 790 (2.4)*	*1.00 (Ref.)*	



Results are adjusted hazard ratios (99% CI) from multiple Cox proportional hazard regression. For better clarity, only variables with at least 1 statistically significant subgroup are shown and the results for the combined variable *surgical experience & operating time* are displayed separately in Fig. 3. Thirty-day complications do not add up to 61,161 as not all registered complication variables were included in the analysis.

Significant *P* values are printed in bold numbers.

CI indicates confidence interval; cm, centimeter; No, number; Ref., reference.

Surgical experience is gained through training. Although it is widely accepted that mistakes are part of the learning process, there is the fundamental obligation to patients that training procedures must not systematically put them at a greater risk for substantial harm than nontraining procedures. As this is so, surgical education traditionally escalates from procedures considered technically less demanding to technically more complex procedures. The traditional view that inguinal hernia repair is one of these simple, beginner procedures has however lately been challenged[27] and whether the practice is still defendable is tightly connected to the potential harm of the procedure and the question whether a systematic risk increase through training procedures exists.

The consequences from the presented study must absolutely not be to bar trainees from performing hernia surgery. Despite statistically significant, absolute numbers of postoperative complications are not calling for immediate action. The results rather demand a more structured supervision of trainees in an assumedly basic procedure as well as a more structured transition toward surgical autonomy. The higher reoperation risk of unsupervised and supervised trainees when OT exceeds 57 minutes demand a structured approach when supervising a procedure and in particular when finally releasing a trainee into more surgical autonomy. A mandatory check of the supervising surgeon after a certain OT could be a way to allow an advanced trainee to develop surgical autonomy and yet ensure that help is readily available, offered, and given.

The 30-day complication results leave more room for interpretation. Notably, the differences were all restricted to OTs longer than 72 minutes. Interestingly, it was specialists and trainee-assisted specialists who were most prone to produce hematoma and surgical site infection. It may be argued that longer OT in procedures performed by specialists is often related to more complex cases. For surgeons in training, increased OT may be considered as an indication that the procedure is challenging, given their level of experience. It should be noted that this study did not find unsupervised trainees or supervised trainees to be an independent risk factor for hematoma or surgical site infection. Procedures exceeding 72 minutes performed by unsupervised trainees were at an increased risk for severe postoperative pain. Reasons for that are speculative

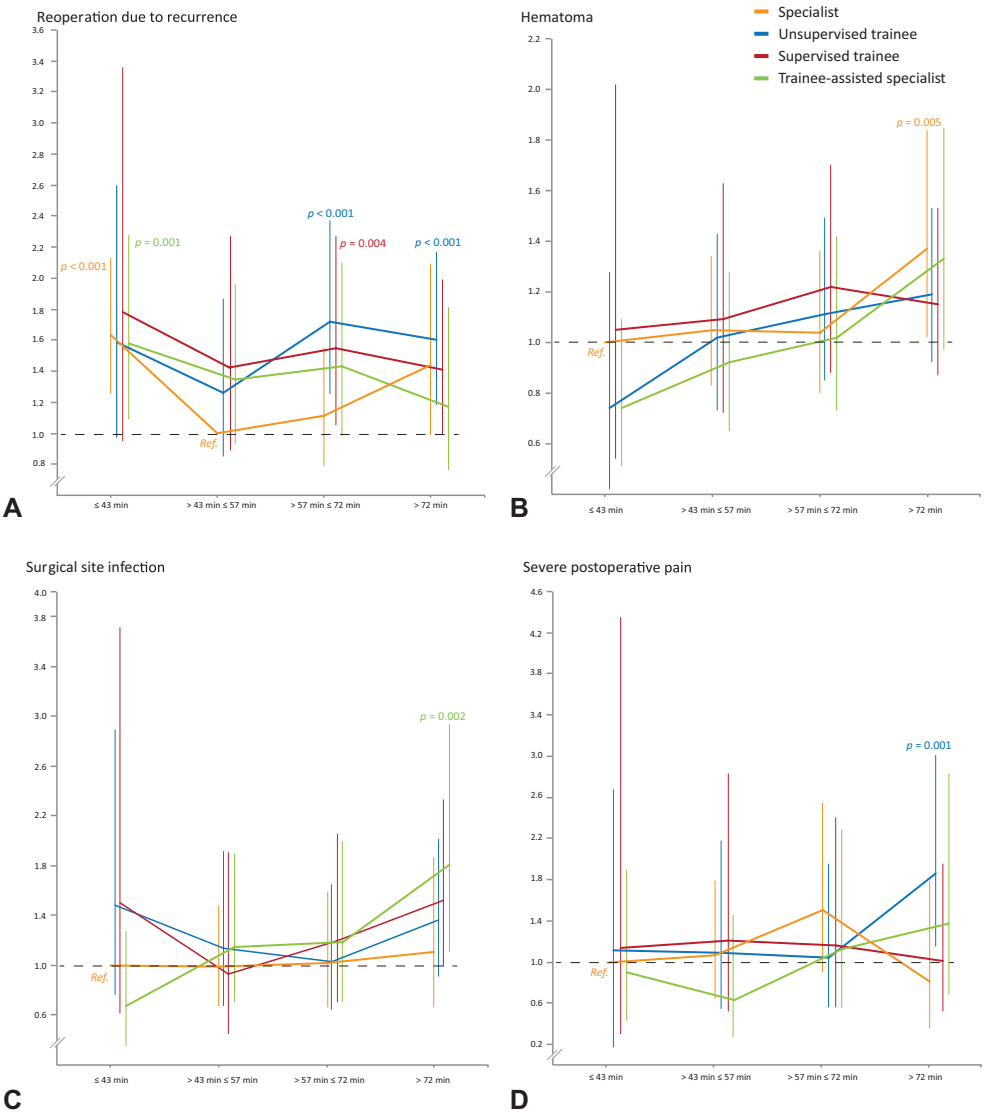
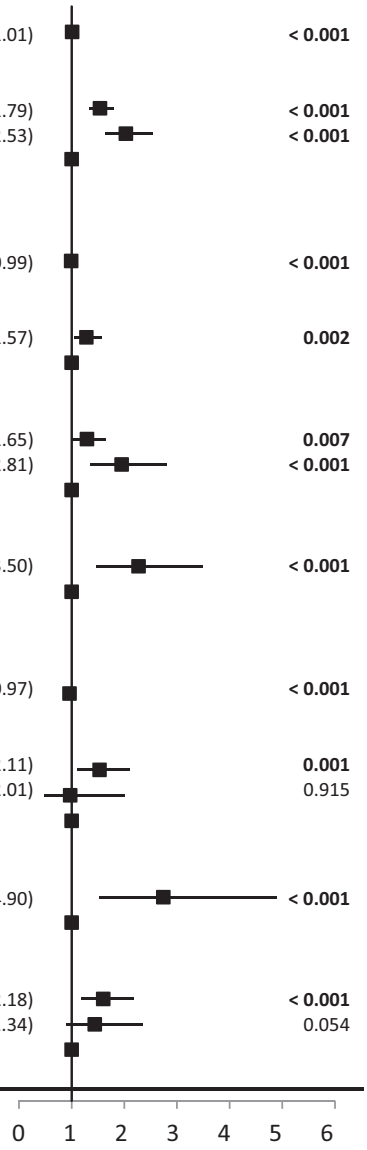


FIGURE 3. Hazard ratio and odds ratio for postoperative outcome related to operating time and level of experience. Hazard ratio for reoperation due to recurrence is displayed on the y-axis in (A); odds ratio for hematoma, surgical site infection, and severe postoperative pain is displayed on the y-axis in (B–D), respectively. Every data-point in the figures represents 1 of the 16 categories of the combined variable *surgical experience & operating time*. Error bars indicate 99% confidence interval. *Ref.* indicates the respective reference group in the figures and the table. The displayed table specifies statistically significant data from (A–D). CI indicates confidence interval; HR, hazard ratio; OR, odds ratio; OT, operating time.

Type of complication	Characteristic	OT quartile (min)	n/No. at risk (%)	HR/OR (99% CI)	*p*-value
Recurrence	Unsupervised trainees	> 72	159/5 768 (2.8)	1.60 (1.18 – 2.17)	< 0.001
	Unsupervised trainees	> 57 ≤ 72	124/4 173 (3.0)	1.72 (1.25 – 2.37)	< 0.001
	Supervised trainees	> 57 ≤ 72	68/2 613 (2.6)	1.55 (1.05 – 2.27)	0.004
	Specialists	≤ 43	322/10 735 (3.0)	1.63 (1.25 – 2.13)	< 0.001
	Trainee-assisted specialists	≤ 43	79/2 928 (2.7)	1.58 (1.09 – 2.27)	0.001
	Specialists (Reference)	*> 43 ≤ 57*	*133/7 595 (1.8)*	*1.00 (Ref.)*	
Hematoma	Specialists	> 72	119/3 054 (3.9)	1.38 (1.03 – 1.85)	0.005
	Specialists (Reference)	*≤ 43*	*268/10 735 (2.5)*	*1.00 (Ref.)*	
Surgical site infection	Trainee-assisted specialists	> 72	42/2 406 (1.7)	1.81 (1.12 – 2.93)	0.002
	Specialists (Reference)	*≤ 43*	*101/10 735 (0.9)*	*1.00 (Ref.)*	
Severe postoperative pain	Unsupervised trainees	> 72	57/5 768 (1.0)	1.84 (1.14 – 2.98)	0.001
	Specialists (Reference)	*≤ 43*	*61/10 735 (0.6)*	*1.00 (Ref.)*	

TABLE 3. Risk Factors for 30-d Complications in 61,161 Males With Open Anterior Mesh Repair for Primary Inguinal Hernia Between January 1, 2002, and December 31, 2014

Complication	Characteristic	Complication rate [n/No. at risk (%)]	Odds ratio [99% CI]	p
Hematoma				
	Age (continuous)	-	1.01 (1.00 – 1.01)	**< 0.001**
	ASA class			
	ASA 2	759/21 120 (3.6)	1.54 (1.33 – 1.79)	**< 0.001**
	ASA 3	246/5 063 (4.9)	2.03 (1.63 – 2.53)	**< 0.001**
	ASA 1 (Ref.)	*747/34 978 (2.1)*	*1.00 (Ref.)*	
Surgical site infection				
	Age (continuous)	-	0.99 (0.98 – 0.99)	**< 0.001**
	BMI			
	Pre-obesity/class I obesity	362/28 836 (1.3)	1.28 (1.05 – 1.57)	**0.002**
	Normal-/underweight (Ref.)	*309/32 325 (1.0)*	*1.00 (Ref.)*	
	ASA class			
	ASA 2	234/21 120 (1.1)	1.29 (1.01 – 1.65)	**0.007**
	ASA 3	77/5 063 (1.5)	1.95 (1.35 – 2.81)	**< 0.001**
	ASA 1 (Ref.)	*236/34 978 (0.7)*	*1.00 (Ref.)*	
	Surgical priority			
	Acute	40/1 746 (2.3)	2.27 (1.47 – 3.50)	**< 0.001**
	Elective (Ref.)	*631/59 415 (1.1)*	*1.00 (Ref.)*	
Severe postoperative pain				
	Age (continuous)	-	0.96 (0.95 – 0.97)	**< 0.001**
	ASA class			
	ASA 2	129/21 120 (0.6)	1.53 (1.11 – 2.11)	**0.001**
	ASA 3	15/5 063 (0.3)	0.97 (0.47 – 2.01)	0.915
	ASA 1 (Ref.)	*360/34 978 (1.0)*	*1.00 (Ref.)*	
	Surgical priority			
	Acute	22/1 746 (1.3)	2.74 (1.53 – 4.90)	**< 0.001**
	Elective (Ref.)	*358/59 415 (0.8)*	*1.00 (Ref.)*	
	Type of hernia			
	Medial	170/22 016 (0.8)	1.60 (1.18 – 2.18)	**< 0.001**
	Combined	37/5 713 (0.6)	1.44 (0.89 – 2.34)	0.054
	Lateral (Ref.)	*173/33 432 (0.5)*	*1.00 (Ref.)*	



Results are adjusted odds ratios (99% CI) from multinomial logistic regression. Thirty-day complications are subgrouped in *hematoma*, *surgical site infection*, and *postoperative pain*. For better clarity, only variables with at least 1 statistically significant subgroup are shown and the results for the combined variable *surgical experience & operating time* are displayed separately in Fig. 3.

Significant *P* values are printed in bold numbers.

CI indicates confidence interval; cm, centimeter; No., number; Ref, reference.

but might be based on ineffective tissue preparation in challenging situations, mirrored in longer OT, which could lead to damage or irritation of inguinal nerves.

The study cohort was distinctly specified. Despite these inclusion criteria, the study comprises to date the largest hernia-specific cohort with regards to the posed question. It can be argued that the selection introduces bias and is a weakness in terms of generalizability. However, in order to arrive at firm conclusions and not to confound the complex interdependence of OT, surgical experience, and outcome by including factors that might increase the risk of adverse outcome irrespective of surgical competence, the study needed to be performed on a large cohort of cases that should be suitable for surgery with trainee participation. For example, female patients with inguinal hernia were excluded as guidelines

recommend using endoscopic techniques for them; proficiency of endoscopic techniques was not part of the Swedish educational syllabus for general surgeons during the study period. In order not to introduce biased cut-offs while wanting to exclude erroneous data entries, outliers of the variable *operating time* were excluded, which is another possible selection bias. Post-hoc subgroup analysis however indicated that procedures with trainee involvement and outlier OTs did not result in higher reoperation rates or 30-day complications rates; thus, it was decided not to include them in order to keep the cohort limited to typical trainee cases. A further point of critique can be seen in the imprecise registration of formal experience. This study only discriminates between surgeons and surgeons-in-training, as year of training is not recorded in the SHR. Thus, this study is not able to draw specific conclusions about differences in outcomes depending on how many years of training the trainee has had.

In conclusion, the presented study shows that anterior mesh repairs for primary inguinal hernia in males are at a greater risk for reoperation due to recurrence when a surgical trainee is the primary surgeon and certain OTs are exceeded. This should not lead to trainees being barred from performing procedures but rather center attention on the concept that longer OT, even at the seemingly simple procedures, can be a sign of disparity between the surgical challenge and the trainee's individual surgical experience. Inguinal hernia repair is a procedure with potential non-negligible risks for patients when performed inadequately and it is thus not acceptable to leave trainees to their own devices at a too early stage of their training. It is imperative to provide organizational and collegial structures that offer easily accessible hands-on guidance for trainees on their way toward surgical autonomy.

REFERENCES

1. Rutkow IM, Robbins AW. Demographic, classificatory, and socioeconomic aspects of hernia repair in the United States. *Surg Clin North Am*. 1993;73:413–426.
2. Malangoni MA, Biester TW, Jones AT, et al. Operative experience of surgery residents: trends and challenges. *J Surg Educ*. 2013;70:783–788.
3. Burcharth J. The epidemiology and risk factors for recurrence after inguinal hernia surgery. *Dan Med J*. 2014;61:B4846.
4. Sandblom G, Gruber G, Kald A, et al. Audit and recurrence rates after hernia surgery. *Eur J Surg*. 2000;166:154–158.
5. Kald A, Nilsson E, Anderberg B, et al. Reoperation as surrogate endpoint in hernia surgery. A three year follow-up of 1565 herniorrhaphies. *Eur J Surg*. 1998;164:45–50.
6. Kim BD, Hsu WK, De Oliveira GS, et al. Operative duration as an independent risk factor for postoperative complications in single-level lumbar fusion: an analysis of 4588 surgical cases. *Spine (Phila Pa 1976)*. 2014;39:510–520.
7. Advani V, Ahad S, Gonczy C, et al. Does resident involvement effect surgical times and complication rates during laparoscopic appendectomy for uncomplicated appendicitis? An analysis of 16,849 cases from the ACS-NSQIP. *Am J Surg*. 2012;203:347–351. discussion 351-352.
8. Aguilar B, Sheikh F, Pockaj B, et al. The effect of junior residents on surgical quality: a study of surgical outcomes in breast surgery. *Am J Surg*. 2011;202:654–657. discussion 657-8.
9. Papandria D, Rhee D, Ortega G, et al. Assessing trainee impact on operative time for common general surgical procedures in ACS-NSQIP. *J Surg Educ*. 2012;69:149–155.
10. Naiditch JA, Lautz TB, Raval MV, et al. Effect of resident postgraduate year on outcomes after laparoscopic appendectomy for appendicitis in children. *J Laparoendosc Adv Surg Tech A*. 2012;22:715–719.
11. Kiran RP, Ahmed Ali U, Coffey JC, et al. Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program. *Ann Surg*. 2012;256:469–475.
12. Davis SS, Husain FA, Lin E, et al. Resident participation in index laparoscopic general surgical cases: impact of the learning environment on surgical outcomes. *J Am Coll Surg*. 2013;216:96–104.
13. Frisén A, Starck J, Smeds S, et al. Analysis of outcome of Lichtenstein groin hernia repair by surgeons-in-training versus a specialized surgeon. *Hernia*. 2011;15:281–288.
14. Wilkiemeyer M, Pappas TN, Giobbie-Hurder A, et al. Does resident post graduate year influence the outcomes of inguinal hernia repair? *Ann Surg*. 2005;241:879–882. discussion 882-884.
15. Kazaure HS, Roman SA, Sosa JA. The resident as surgeon: an analysis of ACS-NSQIP. *J Surg Res*. 2012;178:126–132.
16. Ross SW, Oommen B, Kim M, et al. A little slower, but just as good: postgraduate year resident versus attending outcomes in laparoscopic ventral hernia repair. *Surg Endosc*. 2014;28:3092–3100.
17. Raval MV, Wang X, Cohen ME, et al. The influence of resident involvement on surgical outcomes. *J Am Coll Surg*. 2011;212:889–898.
18. Robson AJ, Wallace CG, Sharma AK, et al. Effects of training and supervision on recurrence rate after inguinal hernia repair. *Br J Surg*. 2004;91:774–777.
19. Jan A, Riggs DR, Orlando KL, et al. Surgical outcomes based on resident involvement: what is the impact on vascular surgery patients? *J Surg Educ*. 2012;69:638–642.
20. Castleberry AW, Clary BM, Migaly J, et al. Resident education in the era of patient safety: a nationwide analysis of outcomes and complications in resident-assisted oncologic surgery. *Ann Surg Oncol*. 2013;20:3715–3724.
21. Benchimol EI, Smeeth L, Guttmann A, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. *PLoS Med*. 2015;12:e1001885.
22. The Swedish Hernia Register [Internet]. Available at: http://www.svensktbrackregister.se. [cited July 22, 2019].
23. HerniaSurge Group. *International guidelines for groin hernia management. Hernia.* 2nd ed. Paris: Springer; 2018, 22:1–165.
24. Feeney T, Price LL, Chen L, et al. Resident and fellow participation in thyroid and parathyroid surgery: an ACS-NSQIP clinical outcomes analysis. *J Surg Res*. 2017;220:346–352.
25. Maggino L, Liu JB, Ecker BL, et al. Impact of operative time on outcomes after pancreatic resection: a risk-adjusted analysis using the American College of Surgeons NSQIP Database. *J Am Coll Surg*. 2018;226:844–857. e3.
26. van der Linden W, Warg A, Nordin P. National register study of operating time and outcome in hernia repair. *Arch Surg*. 2011;146:1198–1203.
27. Sanders DL, Kingsnorth AN, Windsor ACJ. Is there a role for hernia subspecialists? Or is this a step too far? *Hernia*. 2016;20:637–640.