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ORIGINAL ARTICLE

Pelvic examination may be meaningfully taught to novices and be used to predict operating times for laparoscopic excision of endometriosis in one surgical procedure

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Objective: To investigate whether pelvic examination may be meaningfully taught to novice medical students and its accuracy in predicting operating times for laparoscopic excision of endometriosis at a single surgical procedure.

Methods: Women with suspected endometriosis scheduled for laparoscopy underwent pelvic examination to estimate operative time by medical students (novices), trainees, senior clinicians with <10 years surgical experience (experts) and ≥10 years (masters). Examination and intraoperative findings were compared and stage of disease recorded.

Results: There were 138 estimations of operating time at the initial assessment and 251 estimations of operating time prior to surgery. The median surgical duration was 44 min (range 12–398) and increased progressively with revised American Society for Reproductive Medicine disease stage. Clinical predictions exceeded actual operating times by a median of 18 min (range overestimating by 180 min and underestimating by 120 min) with 80% of procedures completed in less time than predicted and none requiring a second procedure. There was no statistical difference in operative time estimations between the groups with students and trainees underestimating surgical duration by a median of two and five minutes, respectively, experts having a median time difference of zero minutes, and masters overestimating by 4.5 min.

Conclusion: Targeted pelvic examining may be taught to novices (medical students) and can be used to predict operating time at one surgical procedure. Less experienced examiners have a tendency to underestimate surgical duration, with masters overestimating surgical time when scheduling laparoscopies for endometriosis, and increasing disease stage is associated with a less precise estimation of surgical duration.

KEYWORDS
endometriosis, laparoscopy, medical education, operating time

INTRODUCTION

Laparoscopic surgery is the accepted standard for diagnosis and management of endometriosis, resulting in significant decrease in pain and improvement in quality of life.[1,2] Endometriosis affects up to 10% of women, of which 30% undergo more than one laparoscopic procedure. It is a commonly performed operation accounting for 33% of gynaecological surgery.[3]

For optimal use of surgical facilities, it would be ideal to accurately estimate surgical duration and perform a single, rather than multiple procedures for the same presentation. This reduces waste of resources and facility costs associated with staffing, and minimises staff fatigue and discontent arising from poor scheduling. Clinical examination is of limited value to determine the location of endometriosis, with previous work reporting variable sensitivity for accurately determining disease sites that range 18–78% even for highly experienced assessors.[4,5]

Few gynaecological studies have investigated the accuracy of estimating surgical duration[6,7] and this study aims to assess the accuracy of clinical examination in predicting surgical time. The capacity to teach and learn such skills is imperative, since clinicians with variable skills and exposure levels are required to perform pelvic examinations, and we investigate the capacity to teach medical students clinical skills to determine location of disease and estimation of surgical time.

MATERIALS AND METHODS

This study was approved by South Eastern Sydney Local Health District Human Research Ethics Committee (HREC number: 14/G/098) using a prospective, multicentre, observational approach and recruiting women over the age of 18 counselled and consented for a diagnostic or therapeutic laparoscopy from private and public clinics and having surgery under the care of any of five consultant gynaecologists.

Following recruitment, data were recorded, including: presenting complaints of dysmenorrhea, non-cyclic pelvic pain, dyspareunia, dysuria or dyschezia; presence and duration of infertility; previous surgery for endometriosis and sonographic findings of ovarian or other disease. Physical examination findings suggestive of full thickness vaginal disease at speculum examination, the position, size and mobility of the uterus, presence, fixation and size of adnexal masses, adnexal tenderness, and tenderness, thickening or nodularity of the uterosacral ligaments, pelvic sidewalls or rectum, were recorded. Based on their findings, examiners predicted an expected disease stage according to the revised American Society for Reproductive Medicine (rASRM) classification and an expected operating time for the recommended surgical procedures. Examiners consisted of a consistent team of gynaecological trainees and consultants across four study sites and examinations were undertaken by a variety of skill levels defined as novices if they were undergraduate medical students ($n = 6$), trainees if physicians were currently enrolled in a gynaecological training program ($n = 8$), experts if physicians had <10 years clinical experience in surgical practice ($n = 7$) and masters if physicians had ≥10 years of experience as specialised gynaecological consultants in endometriosis surgery ($n = 2$). Novices were medical students who had completed an undergraduate term in general obstetrics and gynaecology and were completing a year of research with the study team. They were taught targeted examinations by trainees, experts and masters specifically for endometriosis in a centre with a high-volume caseload of this disease. They observed ten procedures and undertook 20 examinations on women with endometriosis before making study assessments. The examining team were blinded to each other's estimations at the time of booking, but were not blinded to available sonography when this was included in the referral, in keeping with a pragmatic approach to surgical booking.

At the time of surgery and following standard practice in our unit, a pelvic examination was performed under anaesthesia by the operating team with examiners blinded to previous assessments. Where there were two surgeons performing examinations, examiners were blinded to each other's findings. The same findings were recorded as in outpatient assessments.

Laparoscopy proceeded in a standardised manner with sites of disease recorded, including: superficial and/or deep lesions of the uterovesical fold, ovaries, uterosacral ligaments, pelvic sidewalls, pararectal regions, pouch of Douglas and rectum; presence/size of ovarian endometriomas; adhesions around the ovaries or ovarian tubes and partial or complete obliteration of the pouch of Douglas. Deep disease was defined as any lesion extending ≥5 mm retroperitoneally, and superficial disease as a depth of infiltration of <5 mm.[5,8] Surgery aimed for complete resection of all lesions at index surgery with tissue sent for histopathological confirmation. Surgeries were staged according to rASRM classification, and length of surgery was recorded as the time between the first incision and the completion of the last suture.

Statistical analyses were undertaken using SPSS Statistics for Mac, Version 22.0 (IBM, Armonk, NY, USA). Data were tested for normality using Shapiro–Wilk test with parametric or non-parametric tests used as appropriate for the data comparisons. Pearson's χ^2 or Fisher's exact test were used to compare examination and surgical findings. Bland–Altman plots were used when calculating differences between surgical and predicted time. Significance was reported at $P < 0.05$. Subgroup analysis of accuracy to predict surgical time was undertaken using four levels of seniority: novices, trainees, experts and masters.

RESULTS

Between March 2014 and April 2015, 168 women entered the study. There were 14 exclusions; four as surgical duration was

TABLE 1 Physical examination findings in clinical and preoperative settings, compared to surgical findings and subdivided by experience level

Examination findings	Sensitivity % (*n*) [95% CI]	Specificity % (*n*) [95% CI]	PPV % (*n*) [95% CI]	NPV % (*n*) [95% CI]	*P*-value
Clinical examination compared with operative findings					
Pouch of Douglas obliteration	61 (14/23) [36–79]	92 (85/92) [85–97]	67 (14/21) [41–85]	90 (85/94) [83–96]	
Uterosacral disease	67 (91/135) [59–75]	49 (47/96) [39–59]	65 (91/140) [57–73]	52 (47/91) [41–62]	
Adnexal disease	30 (17/56) [18–43]	96 (140/146) [91–99]	74 (17/23) [50–89]	78 (140/179) [71–84]	
Ovarian endometriosis	33 (15/45) [19–48]	99 (174/178) [94–99]	79 (15/19) [52–94]	85 (174/204) [80–90]	
Sidewall disease	18 (26/142) [12–26]	74 (72/98) [64–82]	50 (26/52) [36–64]	38 (72/188) [31–46]	
Rectal disease	36 (5/14) [9–61]	97 (98/101) [92–99]	63 (5/8) [18–90]	92 (98/107) [85–96]	
Preoperative examination (under general anaesthesia) compared with operative findings					
Pouch of Douglas obliteration	56 (28/50) [39–69]	95 (188/198) [91–98]	74 (28/38) [55–86]	90 (188/210) [85–93]	
Vaginal endometriosis	65 (11/17) [29–82]	98 (220/225) [95–99]	67 (10/15) [32–86]	97 (220/226) [94–99]	
Ovarian endometrioma	31 (27/88) [21–41]	96 (393/410) [93–98]	61 (27/44) [46–76]	87 (393/454) [83–90]	
Adnexal adhesions	62 (27/44) [46–76]	80 (315/393) [76–84]	26 (27/105) [18–35]	95 (315/393) [92–97]	
Uterosacral ligament disease	63 (164/264) [56–68]	73 (159/218) [67–79]	74 (164/223) [67–79]	61 (159/259) [55–67]	
Sidewall disease	17 (45/259) [13–23]	96 (163/170) [92–98]	87 (45/52) [74–94]	43 (163/377) [38–48]	
Rectal disease	23 (7/30) [8–41]	96 (207/229) [93–98]	47 (7/15) [18–71]	90 (207/229) [86–94]	
Preoperative examination (under general anaesthesia) compared with operative findings, divided by experience level					
Pouch of Douglas obliteration					
Novice	†	†	†	†	†
Trainee	40 (6/15) [16–68]	97 (68/70) [90–100]	75 (6/8) [35–97]	88 (68/70) [79–95]	<0.001§
Expert	54 (7/13) [25–81]	95 (53/56) [85–99]	70 (7/10) [35–93]	90 (53/59) [79–96]	<0.001§
Master	82 (13/16) [54–96]	91 (40/44) [78–98]	77 (13/17) [50–93]	93 (40/43) [81–99]	<0.001§
Ovarian endometrioma					
Novice	17 (1/6) [0–64]	95 (55/58) [86–99]	25 (1/4) [1–81]	92 (55/60) [82–97]	0.332§
Trainee	27 (7/26) [12–48]	98 (147/150) [94–100]	70 (7/10) [35–93]	89 (147/166) [83–93]	<0.001§
Expert	30 (8/27) [14–50]	94 (104/111) [87–97]	53 (8/15) [27–78]	85 (104/123) [77–90]	0.002§
Master	38 (11/29) [21–58]	96 (87/91) [89–99]	73 (11/15) [45–92]	83 (87/105) [74–90]	<0.001
Adnexal adhesions					
Novice	†	†	†	†	†
Trainee	15 (5/34) [5–31]	96 (117/122) [901–99]	50 (5/10) [19–81]	80 (117/146) [73–86]	0.041§

(Continues)

TABLE 1 (Continued)

Examination findings	Sensitivity % (*n*) [95% CI]	Specificity % (*n*) [95% CI]	PPV % (*n*) [95% CI]	NPV % (*n*) [95% CI]	*P*-value
Expert	39 (13/33) [23–58]	95 (92/97) [88–98]	72 (13/18) [47–90]	82 (92/112) [74–89]	<0.001§
Master	28 (9/32) [14–47]	93 (67/72) [85–98]	64 (9/14) [34–87]	74 (67/90) [64–83]	0.01§
Uterosacral ligament disease					
Novice	30 (7/23) [13–53]	79 (27/34) [62–91]	50 (7/14) [23–77]	63 (27/43) [47–77]	0.397‡
Trainee	39 (32/83) [28–50]	85 (72/85) [75–92]	71 (32/45) [56–84]	59 (72/123) [49–67]	0.001‡
Expert	69 (53/77) [57–79]	62 (37/60) [48–74]	70 (53/76) [58–80]	61 (37/61) [47–73]	<0.001‡
Master	89 (72/81) [80–95]	59 (23/39) [42–74]	82 (72/88) [72–89]	72 (23/32) [53–86]	<0.001‡
Sidewall disease					
Novice	†	†	†	†	†
Trainee	7 (6/82) [3–15]	97 (67/69) [90–100]	75 (6/8) [35–97]	47 (67/143) [39–55]	0.29§
Expert	23 (19/81) [15–34]	90 (30/33) [76–98]	86 (19/22) [65–97]	33 (30/92) [23–43]	0.078‡
Master	23 (17/75) [14–34]	94 (29/31) [79–99]	90 (17/19) [70–99]	33 (29/87) [24–44]	0.048‡
Rectal disease					
Novice	†	†	†	†	†
Trainee	33 (3/9) [8–70]	97 (75/77) [91–100]	60 (3/5) [15–95]	93 (75/81) [85–97]	0.007§
Expert	†	†	†	†	†
Master	13 (1/8) [1–53]	98 (50/51) [90–100]	50 (1/2) [1–100]	88 (50/57) [76–95]	0.255§

CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.
†Insufficient data.
‡Pearson's χ^2 test.
§Fisher's exact test.

missing, one conversion to laparotomy and nine women who did not have surgery. Of the 154 women remaining, mean age was 33 years (range 18–52 years) with 125 (81%) women presenting with pain symptoms, including: dysmenorrhea in 123 (80%); non-cyclic pelvic pain in 102 (66%); dyspareunia in 78 (51%); dyschezia in 38 (25%); and dysuria in 17 (11%). Infertility was present in 39 (25.5%) women for a median duration of 18 months (range 8–96 months); 11 (7%) women had ultrasonic diagnosis of an endometrioma alone. A combination of pain, infertility or cysts was present in 29 (19%) women and 49 (32%) had previous surgery for endometriosis.

There were 138 estimations of operating time at outpatient presentation and 251 estimations of operating time under anaesthetic prior to surgery. Prior to surgery, novices performed 32 examinations, trainees 88, experts 69 and masters 60. The median surgical duration was 44 min (range 12–398) increasing with disease stage, with 11 (7%) women having no operative suggestion of disease (median 31 min, range 12–146), 64 (42%) women having stage I (median 35 min, range 12–145), 30 (19%) women having stage II (median 36.5 min, range 16–135), 15 (10%) women having stage III (median 62 min, range 25–185) and 34 (22%) women having stage IV (median 79 min, range 19–398). Six women had additional procedures, including one salpingo-oophorectomy, one dermoid cyst excision and four total laparoscopic hysterectomies. Surgical time in these women was increased by a median of 35 min. For the 143 women with visually suspected disease, endometriosis was histologically confirmed in 122 (85%). From the 21 (15%) women negative for endometriosis, two had endosalpingiosis and one adenomyosis (hysterectomy performed).

Table 1 summarises these results and details the sensitivity, specificity, positive and negative predictive values and *P*-values at various sites of the pelvic examination for localisation of disease.

The clinical prediction of operating time was available for 138/168 (90%) cases. This assessment overestimated the actual time taken to complete surgery by a median of 18 min (range overestimating by 180 and underestimating to 120 min). Thirty-five out of 138 (25%) of these surgeries were completed at least 40 min earlier than expected and 110/138 (80%) were completed in less time than predicted. A Bland–Altman plot of these results is shown in Figure 1a. With increasing surgical duration, there was a greater difference between predicted and actual time, with examiners overestimating more than underestimating surgical duration. When examiners underestimated the time compared with actual surgical time, most cases were completed within 50 min and only 3/154 (2%) exceeded the 95% centile of 53 min.

The examination performed under anaesthesia was more accurate with the difference between estimated and actual operating times having a median of zero minutes and a range of 120 min underestimation to 120 min overestimation. Two hundred and twenty-seven out of 251 (90%) predicted times were within ≤30 min of actual operating time and 50% of predictions occurred within ±15 min of actual operating times. Figure 1b shows the Bland–Altman plot of the time differences at this assessment.

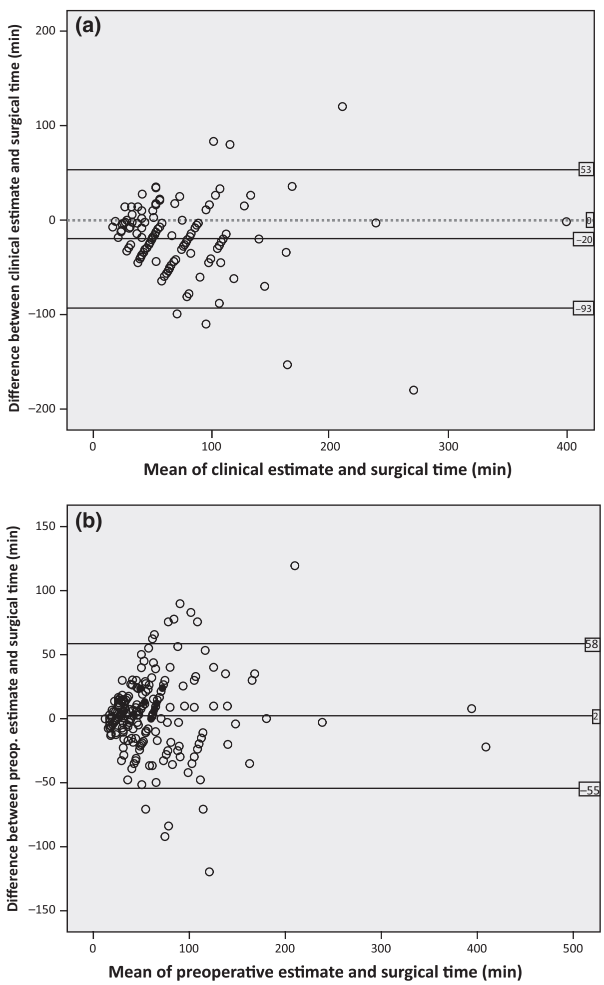

FIGURE 1 Bland–Altman plots comparing clinical (a) and preoperative (b) predictions of operating time to surgical times. For clinical predictions, a reference line (dotted) has been added at a time difference of zero.

Increasing stage of disease was associated with an increased interquartile range with 14/251 (6%) predictions being ±60 min away from actual times.

When analysing surgical estimation of time by level of experience, increasing experience was associated with overestimating the duration of surgery, with students, trainees and experts underestimating surgical duration by a median of 2, 5 and 0 min, respectively, and masters overestimating by 4.5 min. While increasing experience was associated with a narrower range of estimations, there was no statistically significant difference between the groups at estimating surgical time ($P = 0.14$) (Figure 2).

DISCUSSION

When assessing a woman with suspected endometriosis, clinicians rely on historical, clinical and imaging findings to predict the extent of disease.[9,10] While many centres will include routine sonography and/or magnetic resonance imaging for women with endometriosis, this is often negative, with small-volume disease and reliance on clinical history and physical examination is required.[10–13] This study suggests clinical examination is useful when counselling women with suspected endometriosis and predicting the surgical time to complete the procedure, negating the need for a second procedure.[14] It also suggests that the skills of both clinical examination for disease localisation and surgical time prediction may be learned and improved by supervision and experience.

Pelvic examination is low-risk and assists in localising disease especially regions in easy reach of examining fingers such as uterosacral ligaments and the posterior compartment.[15] The accuracy of clinical examinations appears to be site specific. Examination of the uterus correlates well with size and weight of this organ once removed,[16,17] while adnexal examination is less accurate.[18] These skills may be learned, with increased accuracy associated with

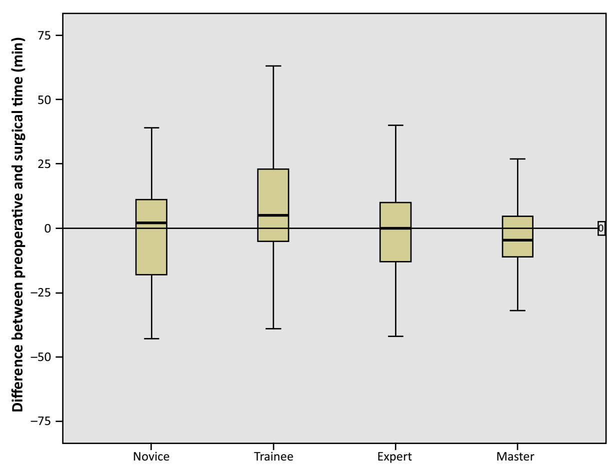

FIGURE 2 Box plots of the differences between preoperative estimates and surgical times for the subcategories of experience levels.

TABLE 2 Summary of predictive ability of clinical examination for different disease sites

	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Right/left ovaries				
Hudelist *et al.* (2009)	38/23	99/99	90/67	92/94
Hudelist *et al.* (2011)	41	99	92	97
Bhatti *et al.* (2015)	33	99	79	85
Right/left uterosacral ligaments (USL)				
Hudelist *et al.* (2009)	52/74	97/89	73/65	96/93
Bazot *et al.* (2009)	74	78	97	24
Hudelist *et al.* (2011)	50	80	43	84
Bhatti *et al.* (2015)	67	49	65	52
Pouch of Douglas (POD)				
Hudelist *et al.* (2009)	70	98	84	95
Hudelist *et al.* (2011)	76	92	64	95
Bhatti *et al.* (2015)	61	92	67	90
Pouch of Douglas and uterosacral ligament				
Abrao *et al.* (2007)	68	46	45	69
Vagina				
Hudelist *et al.* (2009)	64	100	100	96
Bazot *et al.* (2009)	50	87	65	78
Hudelist *et al.* (2011)	73	98	80	97
Rectovaginal space (rectovaginal septum)				
Hudelist *et al.* (2009)	88	99	78	99
Bazot *et al.* (2009)	18	96	40	90
Hudelist *et al.* (2011)	78	98	78	98
Bladder				
Hudelist *et al.* (2009)	25	100	100	98
Hudelist *et al.* (2011)	25	100	100	98
Rectosigmoid				
Abrao *et al.* (2007)	72	54	63	64
Hudelist *et al.* (2009)	46	99	96	85
Bazot *et al.* (2009)	46	72	78	38
Hudelist *et al.* (2011)	39	97	86	84
Bhatti *et al.* (2015)	36	97	63	92
General pelvic exam				
Eskenazi *et al.* (2001)	76	74	67	81

NPV, negative predictive value; PPV, positive predictive value.

greater years of experience and examiners of 30+ years performing the most accurate assessments.[18,19] This was demonstrated in the current study when assessing endometriomata and adnexal adhesions, with increased experience resulting in greater sensitivity in these areas. As an adjunct to other clinical assessments, the results from this study suggest an increasing accuracy in predicting operative time with experience, and a capacity to teach junior and novice clinicians to undertake this assessment quickly and efficiently.

Clinical examination is combined with imaging modalities to improve the accuracy of non-invasive diagnoses and predict the inclusion of specific skill sets such as colorectal colleagues when rectal disease (for example) is present.[4,5,7,20–22] In this study, our pragmatic approach was that examination and imaging studies should be used in conjunction to plan procedural time, since this reflects actual clinical practice. Given that our study had few clinically apparent findings on imaging, its value as an adjunct to examination is not over-represented in this population. Table 2 compares the sensitivities, specificities, positive and negative predictive values for physical examination in previous studies with this study. It suggests that for a non-expert group of clinicians, examinations offer some benefit, although their predictive capacity is variable, and sometimes poor. For experts and masters, there is significant improvement in capacity to predict disease in certain locations and experience improves this skill. Comparing previous data with the results from this study shows similar outcomes for many areas of the pelvic examination and confirms that this is an imperative part of the assessment of the women with suspected endometriosis. Perhaps most important is that while there is a moderate increase in localisation skill with experience, this may be rapidly taught with appropriate supervision and continued clinical practice even at a novice level.

When a procedure is planned, accurate determination of surgical time optimises scheduling and resource utilisation to the benefit of healthcare stakeholders.[3,7,20,23,24] Performing a single procedure rather than 'planning' laparoscopy improves resource allocation and reduces patient risk, since laparoscopic entry is the component associated with most surgical risk.[14,25]

The slight overestimation of surgical time found in this series is similar to a retrospective analysis of 10 831 surgeries that reported a median time difference of 10 min overestimation, with surgeries scheduled for >150 min having a greater difference between scheduled and actual durations.[26] These results are mirrored in this study and corresponded to the suspicion of a higher disease stage with extensive endometriosis often requiring treatment of endometriotic cysts, dissecting pouch of Douglas obliteration, and time-consuming ureter, bladder and rectosigmoid dissections.[21,27,28]

Optimising operating theatre (OT) efficiency is often targeted by healthcare providers as a key performance indicator and it has been suggested that OTs should have a prediction bias of <15 min for every eight hours of OT time for maximum efficiency.[29,30] Economic models have suggested that if all cases start within 15 min of their scheduled time, and no procedures run 15 min past scheduled 'end of day', utilisation rates of 85–90% may be achieved[31] – and this target is cited by providers.[30] In this real-life study where 25% of cases were completed 40 min early, and 50% completed 18 min early, for sites performing high-volume endometriosis surgery in a single day, this may allow additional cases to the OT – either as elective or emergencies – to reach this target efficiency.[32] This 'release' of OT time may benefit the healthcare facility without compromising an elective schedule.

Examination in clinical settings demonstrated difficulty in localising pelvic disease, as endometriosis is often small-volume and not easily palpable in clinical settings where pain may limit examination of deep structures. Perhaps not surprisingly then, the preoperative estimations of surgical time under anaesthetic were more accurate, and the near-negligible differences in preoperative estimations indicate that gynaecologists perform remarkably well preoperatively with over- and under-estimations likely to negate each other during a surgical list. Unfortunately, since scheduling will have already occurred prior to the anaesthetised examination, this information cannot be used to assist in the scheduling of operating lists and is more of academic interest, rather than providing useful information for surgical planning.

One of the limitations of this study was that operating surgeons performing estimations were also performing surgery, as is appropriate, and it is not possible to blind for this. It is possible, but not probable that surgical time was adjusted according to estimations made, but this would require close monitoring of actual time during the case, and may involve waiting to complete the case to close the skin and this did not occur. The sensitivity analyses by experience level showed no statistical differences in estimating surgical time; however, regression to a mean, the small magnitude of the estimations and the Hawthorne effect may be present.

In conclusion, this study demonstrates that targeted pelvic examination skills improve with training and practice; and although more experienced examiners perform more accurate physical assessments, the fact that this then does not result in more accurate estimations of operating time suggest that examination findings are only one component of the complex method of predicting operating times. Operating times may be influenced by surgeon characteristics, team composition, hospital organisation, patient characteristics and even time of day.[24] These are all possible explanations for the variation between studies that attempt to correlate clinical findings with disease location and how this influences estimations of surgical time.

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