

Validity of a cross-specialty test in basic laparoscopic techniques (TABLT)

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Background: Box trainer systems have been developed that include advanced skills such as suturing. There is still a need for a portable, cheap training and testing system for basic laparoscopic techniques that can be used across different specialties before performing supervised surgery on patients. The aim of this study was to establish validity evidence for the Training and Assessment of Basic Laparoscopic Techniques (TABLT) test, a tablet-based training system.

Methods: Laparoscopic surgeons and trainees were recruited from departments of general surgery, gynaecology and urology. Participants included novice, intermediate and experienced surgeons. All participants performed the TABLT test. Performance scores were calculated based on time taken and errors made. Evidence of validity was explored using a contemporary framework of validity.

Results: Some 60 individuals participated. The TABLT was shown to be reliable, with an intra-class correlation coefficient of 0.99 ($P < 0.001$). ANOVA showed a difference between the groups with different level of experience ($P < 0.001$). The Bonferroni correction was used to confirm this finding. A Pearson's r value of 0.73 ($P < 0.001$) signified a good positive correlation between the level of laparoscopic experience and performance score. A reasonable pass–fail standard was established using contrasting groups methods.

Conclusion: TABLT can be used for the assessment of basic laparoscopic skills and can help novice surgical trainees in different specialties gain basic laparoscopic competencies.

Paper accepted 16 April 2015

Published online 11 June 2015 in Wiley Online Library (www.bjs.co.uk). DOI: 10.1002/bjs.9857

Introduction

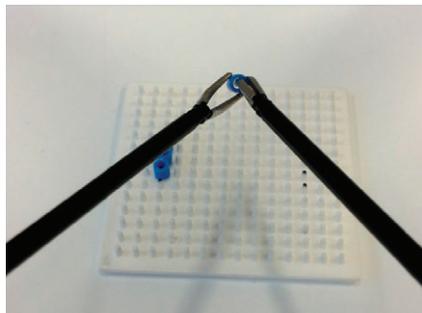
Minimally invasive techniques, and laparoscopy in particular, have become widespread in present clinical practice¹. Training is required to reach competency in laparoscopic skills and, because the level of surgical skill is related directly to the outcome of operation, recent research has highlighted the importance of competence². Laparoscopic surgery requires specific psychomotor skills as depth perception is missing, instruments are fixed at skin level and there is a limited range of movement³. To overcome this, laparoscopic techniques can be trained on box or virtual reality trainers outside the operating theatre. Training surgical skills using a simulator can shorten operating times, increase operative skills, and reduce the risk of both intra-operative and postoperative complications^{4–7}.

Criterion-based assessment and training has gained ground, and it is generally accepted that trainees should

train to reach a predefined level of proficiency^{8,9}. Assessment of skills ensures a relevant level of competency has been reached, and increases the motivation for trainees to practise^{8,10}. This level of competency, however, should be assessed using a test supported by evidence of validity^{11–14}. Until now, training systems for laparoscopy have been developed independently for each specialty (general surgery, urology and gynaecology), including learning advanced skills such as suturing. The Fundamentals of Laparoscopic Surgery (FLS) is the most widespread of these training systems, and is used for credentialing surgeons during specialty training¹⁵. However, there is still a need for a skills training and assessment tool for novice laparoscopic surgeons to use before performing supervised surgery on patients⁸.

The aims of this study were to explore evidence of validity for a test of basic laparoscopy skills, and to establish a reasonable pass–fail standard.

Task 1: coordination



A bead to peg transfer task, in which four beads were transferred from pegs on one side of a pegboard to the other and back again by grasping the bead, transferring the bead from one instrument to another instrument, and then placing it back on the pegboard.

Errors were counted whenever a bead was dropped. If the bead fell outside reaching distance, this was counted as two errors. Each error resulted in 20s of penalty time.

The mean task score for a group of experienced surgeons was 427.

Task 2: cutting

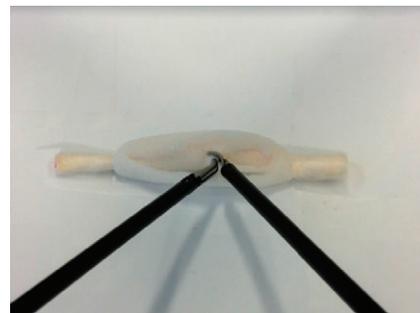


The purpose of this task was to cut a circle with a 2.5-cm radius from a washcloth, while cutting only within a 3-mm thick black line.

Errors were counted for each cut outside the line. Each error resulted in 20s of penalty time.

The mean task score for a group of experienced surgeons was 361.

Task 3: sharp dissection



The objective of this task was to dissect a rolled up washcloth (9 × 9cm), and to locate and view a vessel simulated by a balloon. The task was completed when two 2-mm black horizontal lines 2cm apart were fully exposed.

Errors were counted when damaging the 'vessel'. Each error resulted in 60s of penalty time.

The mean task score for a group of experienced surgeons was 489.

Task 4: blunt dissection

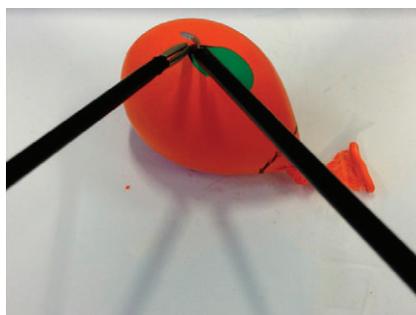


The aim of this task was to dissect a roll of cotton (5 × 9cm) using a blunt technique, and viewing a vessel simulated by a balloon. The task was completed when the 2-mm black lines 2cm apart were fully exposed.

Errors were counted when bits of cotton were torn from the roll as a result of the exercise. Errors resulted in 30s penalty time.

The mean task score for a group of experienced surgeons was 476.

Task 5: cyst removal

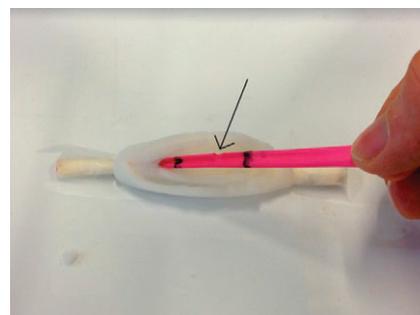


This task consisted of a balloon wrapped inside another balloon. The inner balloon was filled with 60ml ultrasound gel. The objective was to remove the inner balloon from the outer balloon by dissecting the outer balloon.

Errors were counted when the inner balloon was perforated. Errors resulted in 60s of penalty time.

The mean task score for a group of experienced surgeons was 393.

Example of an error



An error has been made in task 3, sharp dissection. The 'vessel' has been damaged.

Fig. 1 Description of tasks and errors



Fig. 2 **a** Training and Assessment of Basic Laparoscopic Techniques (TABLT) training kit, including tasks. **b** Surgical trainee using TABLT

Methods

The study was submitted for evaluation to the regional ethics committee, which determined that no approval was needed (H-3-2013-FSP66).

Training and Assessment of Basic Laparoscopic Techniques

The Training and Assessment of Basic Laparoscopic Techniques (TABLT) test was developed during separate laparoscopy training programmes for general surgeons and gynaecologists. The tasks were developed with a focus on appropriate functional task alignment in order to enhance the transfer of learning¹⁶. Faculty and course participants provided feedback and adjustments were made to ensure relevance of the tasks. A pilot study was performed with two experienced surgeons and eight novices to ensure a reasonable level of difficulty and adjust the scoring system. Five tasks were included in the TABLT test, with its content reflecting basic laparoscopic techniques (Fig. 1). The tasks covered appropriate handling of laparoscopic instruments, cutting, blunt dissection and sharp dissection. The test also considered hand–eye coordination, guiding instruments via a screen, ambidexterity, accommodating the fulcrum effect and economy of movement.

Based on elements used in the FLS training ratings system¹⁷, a scoring system was developed taking account

Table 1 Participants

	Novice (n = 20)	Intermediate (n = 20)	Experienced (n = 20)	Total (n = 60)
Age (years)	24–31	27–41	31–58	24–58
Sex ratio (M : F)	7 : 13	11 : 9	13 : 7	31 : 29
Specialty				
Surgery	11	13	10	34
Urology	3	5	5	13
Gynaecology	6	2	5	13

of time and number of errors (Fig. 1). For each task, a score was calculated by subtracting the time spent on the task and a task-specific penalty score from a maximum time of 600 s, using the formula: task score = 600 – completion time – (no. of errors × penalty time per error).

The task scores were then standardized by dividing the task score by the mean score from a group of experienced surgeons and then multiplying it by 100. A performance score for the whole test was calculated as the sum of the five standardized task scores. The scoring system was tested during the pilot study.

Establishing validity evidence

A cohort of laparoscopic surgeons and surgical trainees were recruited and evidence of validity established using a contemporary framework of validity¹⁴. In accordance with

Table 2 Summary of validity evidence

Source of validity evidence	Questions related to each source of evidence	Validity evidence for TABLT
Content	Does the content reflect the underlying construct?	Tasks are aligned with the construct
Response process	Are sources of bias reduced?	Assessment can be done blinded, and calculation of the score automated
Internal structure	Is the test score reliable?	A high level of reliability shown: ICC = 0.99 ($P < 0.001$)
Relation to other variables	Does the test score correlate with a known measure of competence?	Novices, intermediates and experts score significantly differently ($P \leq 0.003$, ANOVA with Bonferroni correction) Test score correlates with operative experience: Pearson correlation $r = 0.73$ ($P < 0.001$).
Consequences of testing	What are the consequences of the pass–fail score?	Two of 20 of experts failed and two of 20 of novices passed the test

TABLT, Training and Assessment of Basic Laparoscopic Techniques; ICC, intraclass correlation coefficient.

this framework, evidence of validity was collected from five sources: content, response process, internal structure, relation to other variables and consequences of the test. Participants were recruited from three different specialties (general surgery, gynaecology and urology). Participants were recruited by e-mail through departmental heads, consultants responsible for training and direct contacts. They were divided into three groups according to level of laparoscopic experience. Novices had no previous experience in laparoscopic surgery, and less than 2 h of training on either a box trainer or virtual reality trainer; those with an intermediate level of experience had performed between one and 100 laparoscopic procedures; and experienced surgeons had carried out more than 100 laparoscopic procedures. Both intermediate and experienced surgeons were undertaking laparoscopic surgery in their current places of work. The TABLT test was administered on a portable tablet trainer¹⁸ (Fig. 2). Testing was performed after work or on days off, according to participant availability. All performed the TABLT test twice. The first attempt was to familiarize themselves with the set-up and scoring system. The second attempt was used for assessment purposes; it was rated on site by the corresponding author and afterwards by a blinded assessor using a video recording. The blinded assessor was another member of the research group who practised rating using videos recorded during a pilot study. Three videos, with examples of different types of error, were used.

Statistical analysis

Statistical analysis was performed to explore the internal structure. The intraclass correlation coefficient (ICC) was calculated, with single measures and absolute agreement definition. ANOVA was used to explore relationships with other variables. Differences between groups of laparoscopic surgeons with various levels of experience were analysed. A groupwise comparison

using ANOVA with Bonferroni correction was done to identify differences between groups for each of the pairings – novice *versus* intermediate, novice *versus* experienced, and intermediate *versus* experienced surgeons. The Pearson product–moment correlation coefficient was calculated to examine any correlation between the number of procedures performed and the test score. A Pearson's r value of 0.7 was considered an acceptable measure of correlation. $P < 0.050$ was considered statistically significant in the aforementioned tests. The contrasting groups method was used to set the pass–fail level, and the consequence of applying this was reported using relative frequencies converted to percentages. A pass–fail score that passed at least 85 per cent of the experienced surgeons and failed at least 85 per cent of the novices was considered reasonable. SPSS[®] version 20.0 (IBM, Armonk, New York, USA) was used for statistical analysis.

Results

All 60 laparoscopic surgeons and trainees (Table 1) completed the TABLT test twice. The second attempt was rated on site and by a blinded video assessor, resulting in 120 ratings.

Validity evidence is summarized in Table 2. The internal structure was explored by analysing test reliability. A high level of reliability was shown, with an ICC of 0.99 ($P < 0.001$). Relationships with other variables, examined by analysing variation in performance scores between novice, intermediate and experienced surgeons, are shown in Fig. 3. A significant difference between these groups was found ($P < 0.001$). The test discriminated between novices and experienced surgeons ($P < 0.001$), novice and intermediate surgeons ($P = 0.003$), and intermediate and experienced surgeons ($P < 0.001$). There was a correlation between the level of laparoscopic surgical experience and the test score, with a Pearson correlation r value of 0.73 ($P < 0.001$) (Fig. 4). A pass–fail level was established at

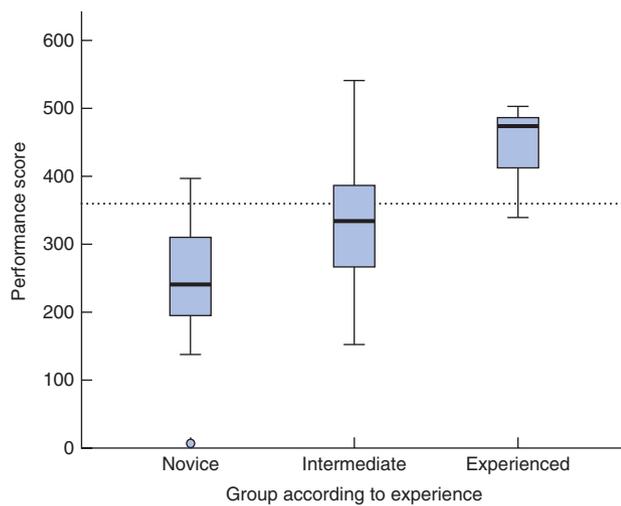


Fig. 3 Box plot of performance scores in relation to level of experience. Median values (horizontal lines), i.q.r. (boxes), and range (error bars) excluding outlier (circle) are shown. The dotted line indicates the pass–fail level. Mean(s.d.) scores for novice, intermediate and experienced surgeons were 244(88), 331(94) and 446(52) respectively

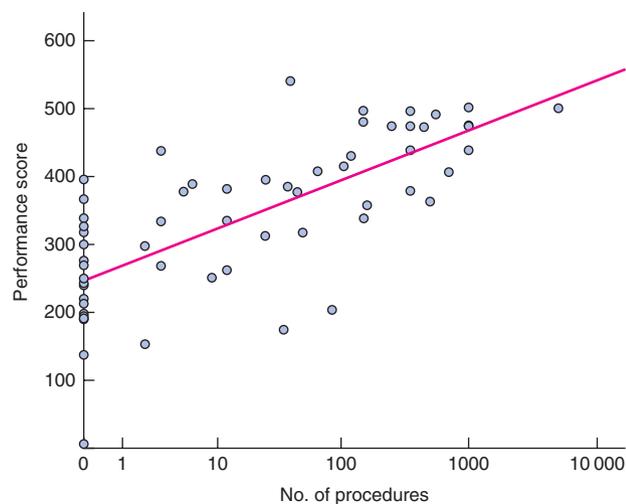


Fig. 4 Performance scores according to the level of experience expressed as number of procedures. Linear $R^2 = 0.526$

358 points using the contrasting groups methods (Fig. 5). The consequence of this pass–fail level was that two of 20 novices passed the test and two of 20 experienced surgeons failed it.

Discussion

The design of TABLT was inspired by another laparoscopic training and testing model, FLS¹⁹. The tasks included in

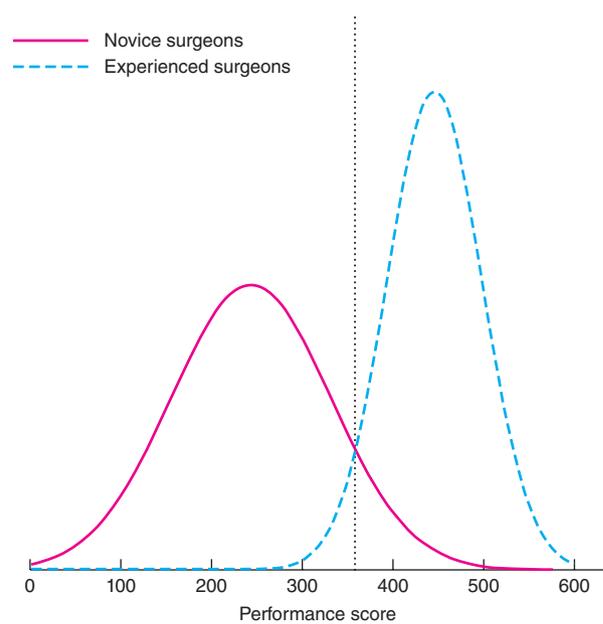


Fig. 5 Standard setting using contrasting groups method. The dotted line indicates the pass–fail level

TABL^T all reflected laparoscopic techniques that ensured a functional alignment of content with the construct, thereby providing evidence of validity from content. In contrast to the FLS, a laparoscopic suturing task was not included in TABLT, because this was considered a more advanced laparoscopic skill not performed by most novices. Camera navigation, on the other hand, is an essential skill and the focus of the Laparoscopic Skills Training and Testing used in gynaecology²⁰. Camera navigation is a relevant skill to train, but requires a movable camera, which is not currently included in the TABLT test. Other test systems of laparoscopic skills focus on basic movement and coordination skills²¹. TABLT includes these skills, but also surgical techniques such as cutting, blunt dissection and sharp dissection. Cutting and dissection are important laparoscopic techniques to master, especially as functional task alignment is high and it can help with instrument familiarization. The TABLT tasks reflect many of the skills needed when surgical trainees perform their first supervised laparoscopic operation on a patient.

Reducing sources of bias and ensuring that the intended response was elicited when administering the test provided evidence from the response process. Bias from data entry was countered by using simple spreadsheets that were preformatted to perform automatic score calculations. This also facilitated maintenance of data integrity, as data in spreadsheets are easily accessible and automated score calculations are transparent. Participants demonstrated an

appropriate response during testing because their first attempt allowed them to develop a strategy for doing the tasks, and they used this in the second attempt, which was the one used for rating.

The results showed a high ICC value, which demonstrated that the scoring system of the TABLT was reliable. A high level of reliability supports evidence of the internal structure. Simple scoring systems, relying on number of errors and time taken, have proved to be reliable in other tests such as the FLS²². The rating can be made either while the tasks are being performed or afterwards from a video recording. Using video recordings allows blinded rating, which minimizes bias from raters.

Evidence of validity was found from relationships with other variables, as there were significant differences in performance scores between the groups with different levels of experience. Correlation was seen between the level of laparoscopic experience measured by the number of procedures performed and test performance scores. Measuring laparoscopic skills by the number of procedures can be problematic owing to recall bias. However, the number of procedures performed by a surgeon has been shown to correlate well with performance level and patient outcome². Having chosen 100 procedures as the cut-off criterion for experienced surgeons, it seemed reasonable to assume that all experienced surgeons had a sufficient level of competency regarding basic laparoscopic skills.

The pass–fail level was established using the contrasting groups method. Two of 20 novices passed the test, whereas two of 20 experienced surgeons failed. This pass–fail level seems acceptable as it discriminates well between competent and non-competent surgeons. As a result of this, some novices will pass the test after a short training period, and some experienced surgeons will fail. The FLS is also subject to a similar challenge; 18 per cent of competent surgeons are expected to fail the test and 18 per cent of non-competent surgeons to pass¹⁷. When setting a pass–fail level, it is important that it should be achievable by novice trainees⁹. To examine this further, it will be necessary to do more research exploring performance curves of the TABLT test among novice trainees.

Evidence of validity was explored by using a contemporary framework of validity¹⁴. An essential part of this process was to consider threats to validity²³. Threats to validity can be divided into two main categories: construct under-representation and construct irrelevant variance. Construct under-representation occurs when the content of the test does not sufficiently represent the construct. Construct irrelevant variance is a result of systematic bias. An example of a threat from construct under-representation is low reliability. In the present study,

a high ICC was found, indicating that the scoring system of the TABLT test was reliable.

Threats to validity from construct irrelevant variance include: rater-related bias, level of difficulty of the test and unjustifiable methods for setting the pass–fail level²³. The TABLT test can be rated by both direct observation and video recordings. A previous study²⁴ showed that experienced physicians were more highly rated as the result of direct observations than they were for blinded rating. The opposite was true for novices. This type of bias did not seem to influence the TABLT test scores, as demonstrated by the high ICC value. The reason lies in the simplicity of the scoring system, which used only time taken and number of errors made. The scoring system was easy to apply and therefore reduced the risk of rater-related bias. The variety of performance scores by novices and intermediates (*Fig. 3*) demonstrated that the level of difficulty of the test was appropriate. The present study also included a wide variety of experienced surgeons with different levels of experience. Using participants with many skill levels for the test is important, as wide variation in skill levels has been recognized among practising laparoscopic surgeons⁹.

The study included a large number of participants with a wide range of competencies across three surgical specialties. This is a strength of the study because all participants were either practising laparoscopic surgeons or training to be laparoscopic surgeons. The main limitation was the focus on the assessment aspect of the TABLT test. The training element of TABLT still needs to be investigated in more detail. In particular, the standard setting should be explored by allowing trainees to train on TABLT and examine their performance curves. The pass–fail level might be set too low, resulting in trainees reaching an insufficient level of competency. If the level were to be set too high, however, the test would not be fair, and trainees would spend time overtraining, which may not result in a higher level of skill in the operating theatre. This highlights a further limitation, as the transfer of skills from the TABLT to a clinical setting has not been explored. The scoring system, although easy to use and reliable, may be too simple to provide meaningful feedback to the trainees on their performance. Using a preformatted spreadsheet makes score calculations easy and transparent so that trainees themselves may be able to perform self-assessment during training or receive formative feedback from faculty. To ensure that appropriate laparoscopic techniques are acquired, the TABLT scores could be supplemented by feedback or ideas for improvement from an experienced surgeon.

Training models based on FLS have been developed for each surgical specialty^{19,25–27}. Although developed for general surgeons, research has demonstrated the benefits of

the FLS practical test in both urology and gynaecology^{28,29}. The TABLT test was designed to be used in cross-specialty training. The techniques practised are used widely, making it possible for experienced laparoscopic surgeons from one specialty to supervise a trainee from a different specialty. A cross-specialty approach also allows trainees from different specialties to practise together and learn from one another. An added benefit is that hospital departments and simulation centres can pool resources, offering more frequent courses and additional training opportunities. When trainees have mastered basic skills in laparoscopy, they can move on to specialty-specific training, such as operation modules on a virtual reality simulator⁴.

TABLT was developed to be used on a portable tablet trainer¹⁸ (Fig. 2), but may be used in any box trainer. Training on a portable trainer increases the flexibility of training³⁰. Box trainers are in general cost-effective, and have proved to be equally as good as virtual reality trainers for training basic laparoscopic skills³¹. Easy access to basic testing and training in laparoscopy could benefit trainees and, more importantly, their patients.

Acknowledgements

Funding and equipment was provided by the Centre for Clinical Education, Capital Region of Denmark. The instruments used in this trial were donated to the Centre for Clinical Education by Johnson & Johnson. E.T. has received non-restricted educational grants from Johnson & Johnson outside the submitted work.

Disclosure: The authors declare no other conflict of interest.

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Over the past few months, you will have noticed that some of the white space in *B7S* has been used to feature drawings of surgeons in the operating theatre. They are the work of Helen Purdie, an artist from Sheffield who used to work in the NHS. Helen was Research Sister and Surgical Care Practitioner until 2009. The illustrations featured in *B7S* were a part of work undertaken during a 3-month art residency at Claremont Private Hospital in Sheffield. Helen's work is featured in an exhibition 'Surgeons at Work: The Art of the Operation' at the Royal College of Surgeons of England until September 19th, and the full collection of her drawings has been published as a book. You can find out more about Helen at <http://www.helenpurdie.co.uk/w/doku.php>. In the meanwhile, the Editors thank her for allowing the Journal to feature her excellent work.

The *B7S* Editorial Team