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ORIGINAL ARTICLE

Development and implementation of an assessment tool to evaluate technical skills in the insertion of implantable venous access devices, a Prospective Cohort Study

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KEYWORDS
Surgical training;
Competency assessment tool;
Skills;
Implantable venous access devices

Summary
Objective: Based on the Competency Assessment Tool, herein we developed an assessment instrument suitable to evaluate the implantation of central intravenous devices.
Background: Surgical assessment is based mainly on the subjective impressions of the teacher. Based on the ''Competency Assessment Tool'' (CAT) developed for the evaluation of technical surgical skills in minimally invasive colorectal resection, we designed an assessment tool suitable to evaluate the implantation of central venous access devices performed by junior surgical trainees.
Methods: Four major assessments during the different steps of the intervention were used in this evaluation. Each of these tasks was divided into four sub-domains according to surgical skill. In addition to the CAT score, the apprentices' skills were evaluated using a visual assessment that was quantified using an analogue scale (value from 1 to 10). The candidates were classified into junior and senior trainees depending on the number of procedures they had already performed and on their surgical experience.
Results: 71 procedures were evaluated during the study period. Seven senior trainees conducted 43 procedures and five junior trainees performed 28 interventions. The senior trainees had significantly higher CAT scores than junior candidates, and the scores fluctuated according to surgical experience, usually reaching their peak after 10 procedures.
Conclusions: The CAT model is well suited for the assessment of surgical trainees during central venous access device implantation. It enables a close assessment of the learning process and the technical skills of trainees, which helps them improving in a safe, standardized manner.

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Introduction

Surgical training has two main aspects. First, the acquisition of the theoretical concepts related to the pathology and its management; second, the acquisition of surgical techniques, operative strategy and manual skills. Whereas assessment of candidate surgeons can be successfully achieved with objectivity concerning their theoretical knowledge, evaluation of their surgical skills and technical maturity are subjective and, therefore, remain a matter of debate [1]. Over the past 20 years, several authors have tried to develop tools to evaluate surgical skills including scale evaluations and scores. Some are specific to a procedure and structured as a checklist of steps [2]. Others use more general means of evaluating the surgical skill and knowledge required for the procedural technique [1,3]. The OSATS (Objective Structured Assessment of Technical Skill) is among the most cited evaluation tools found in the literature. It is a good tool to evaluate specialised candidates based on their hands-on experience. It has the advantage of using detailed criteria to describe technical skills [1] but does not take into account the different steps and stages within a surgical procedure [4]. Due to reduced work hours and increased demand for objective evidence of qualification, the need for structured learning strategies and skill assessments has become essential in the surgical field [5]. A low number of laparoscopic procedures performed for elective colorectal surgery in Britain has led to a national training program in 2008. They developed and validated a systematic evaluation measure called the ''Competency Assessment Tool'' (CAT). It uses a checklist of the tasks required subdivided into a four-step procedure, thereby enabling the evaluation of candidates' technical skills including errors. This program increased the rate of the colorectal laparoscopic procedure by 50% in 4 years and thus decreased the learning curve for this procedure [6]. During surgical training, implantation of the central venous access device is carried out mainly by trainees under the supervision of experienced surgeons. This procedure is highly standardised and allows for the development of an evaluation tool with separate steps. It combines standard open surgery, dissection of a vessel (cephalic vein), catheterisation techniques and x-ray interpretation at the end of the surgery [7]. Moreover, it is a very common procedure: 400 central venous access devices are implanted in our unit annually. Based on the model already used for laparoscopic colorectal surgery, our aim is to determine the efficacy of the assessment tool we developed for the insertion of central venous access devices.

Materials and methods

Evaluation method

We developed our adapted version of the assessment table used by Miskovic. The CAT designed for laparoscopic colectomy studies subdivides surgery into four stages: exposure, control of the vessels, mobilisation and resection/anastomosis. Each step was evaluated to assess the use of instruments, manipulation of tissues, complications and the result. These sub-skills were rated using a four-point scale: 0 if the step was not performed by the candidate, 1 for incompetent, 2 for novice, 3 for competent and 4 for expert [6].

A video detailing the standard procedure for implantable venous access device insertion through the cephalic vein was available from our service and shown to all novice trainees. The subdivision into four stages was approved by the supervising surgeon. Similarly, the second principle of Miskovic was to detail the assessment of each step in four skills and was applied to the new tool: use of instruments, tissue manipulation, damage and quality of the final result. The expected result was to obtain a CAT successfully adapted to our procedure involving criteria for each specific stage and evaluation of technical skills. A visual analogue scale (VAS) was included in the same document to evaluate the candidate's surgical performance without direct supervision. A rating scale with seven possible answers ranging from ''clearly yes'' to ''clearly no'' was used. The modified CAT was divided into four steps (Table 1):

- installation and dissection until location of the cephalic vein;
- preparation of the cephalic vein;
- introduction of the catheter;
- creation of a subcutaneous space, placement of the device and closure.

A VAS ranging from 1 to 10 allowed us to effectively evaluate the autonomy of the trainee. The autonomy of the trainees was assessed simultaneously using a VAS.

Each step was sub-divided into four skills assessment steps that were evaluated by a score ranging from 1 to 4 (1 for incompetent, uncontrolled or dangerous; 2 inadequate, inefficient or vague; 3 safe or good; 4 expert or perfect). We reserved the evaluation for only those surgeons who carried out the whole procedure.

Data collection

We prospectively analysed 71 evaluations. The recorded data included the CAT, EVA, age and sex of the patient, identity of the candidate and the assessor, position of the catheter, surgical indication, ASA score of the patient, patient's body mass index, difficulty of the case (classified as standard or difficult), number of procedures performed by the applicant before the evaluation (> 10 or < 10), junior or senior status of the candidate (linked to the type of supervisor, junior or senior) and the number of years prior to surgical training.

Interventions requiring help from the assessor, such as help for venepuncture, catheterization of the vein or any other demonstrative help on the part of the assessor, were excluded.

Statistical analysis

The statistical tests were selected and performed with help from the Methodological Support Unit of the Geneva University Hospitals using the CRAN R v. 3.0.3 software (R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/).

The Mann-Whitney U test was used to estimate the difference in the number of procedures performed by junior and senior candidates as well their respective surgical experience. The Receiver Operating Characteristic (ROC) method was used to examine the CAT score threshold required to identify autonomous candidates.

Given the unequal number of observations per candidates, mixed statistical models were used to study other continuous variables, and generalised mixed models for

Table 1 Caracteristics of the modified CAT.

Taxx	Ability to use surgical tools		Tissue handling		Damages		Final quality result	
	Patient installation, surgical incision, use of scalpel		Subcutaneous tissue dissection		Damages due to		Cephalic vein identification	
Patient installation, surgical exposure, vein detection	1. Unqualified	Wrong position Wrong incision Suboptimal exposure	1. Unqualified	Stiff and uncontrolled movements	1. Unqualified	Wrong surgical incision (or requiring correction) Improper dissection	1. No	Cephalic vein not identified
	2. Unsatisfactory	Multiple attempts Suboptimal ergonomic	2. Unsatisfactory	Controlled but hesitant (and sometimes) ineffective movements	2. Unsatisfactory	Bleeding during dissection, muscular injuries	2. Partial	Identification requiring help
	3. Safe	Safe surgical technique Good ergonomic	3. Safe	Controlled and effective movements	3. Safe	Effective dissection	3. Yes	Successful identification after multiple attempts but without help
	4. Expert	Optimal installation and ergonomic	4. Expert	Ability to predict Perfect movements	4. Expert	Effective dissection with optimal tissue preservation	4. Expert	Perfectly anatomical dissection
	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable
Taxxx	Ability to use surgical tools		Tissue handling		Damages		Final quality result	
	Use of mixter right angle forceps		Vein handling, denudation and distal tying		Damages due to		Cephalic vein preparation for catheterism	
Surgical vein approach	1. Unqualified	Wrong use with uncontrolled movements	1. Uncontrolled	Poor exposure High-risk handling	1. Uncontrolled	Major venous injury	1. Uncontrolled	Impossible
	2. Unsatisfactory	Controlled but hesitant and multiple movements	2. Ineffective	Hesitant handling	2. Ineffective	Bleeding due to minor venous injury	2. Imprecise	Unsatisfactory preparation
	3. Safe	Good use of surgical tools	3. Good	Effective dissection	3. Good	No vascular injuries	3. Good	Satisfactory preparation
	4. Expert	Very good use of surgical tools	4. Expert	Effective dissection Low-risk handling	4. Expert	Perfect dissection	4. Expert	Very good preparation
	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable

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Table 1 (*Continued*)

Taxx	Ability to use surgical tools		Tissue handling		Damages		Final quality result	
	Patient installation, surgical incision, use of scalpel		Subcutaneous tissue dissection		Damages due to		Cephalic vein identification	
Taxxx	Ability to use surgical tools		Tissue handling		Damages		Final quality result	
	Venotomy		Insertion of venous access device		Damages due to		Cephalic vein catheterism and radiologic images	
Insertion of venous access device	1. Unqualified	Complete venous section	1. Uncontrolled	Poor exposure High-risk handling	1. Uncontrolled	Major venous injury or sterility compromised	1. No	Impossible
	2. Unsatisfactory	Multiple tries with hesitant movements	2. Ineffective	Multiple tries with hesitant movements	2. Ineffective	Vascular injury (w/o consequences)	2. Partial	Procedure corrected by the teacher
	3. Safe	Good use of surgical tools	3. Good	Effective introduction, low-risk profile	3. Good	No vascular injuries	3. Good	Good placement
	4. Expert	Very good use of surgical tools with high security	4. Expert	Very good introduction	4. Expert	Perfect introduction	4. Expert	Perfect autonomous Result w/o any help
	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable
Taxxx	Ability to use surgical tools		Tissue handling		Damages		Final quality result	
	Electro cautery, needle driver		Subcutaneous pocket preparation, connection and port placement		Damages due to		Functional port placement	
Subcutaneous pocket preparation and port placement	1. Unqualified	Uncontrolled use with high-risk profile	1. Uncontrolled	Uncontrolled, and hesitant movements	1. Uncontrolled	Tissue or material injuries, compromised sterility	1. No	Wrong port placement
	2. Unsatisfactory	Multiple tries with hesitant movements	2. Ineffective	Multiple tries with hesitant movements	2. Ineffective	Port placement ineffective	2. Partial	Help required
	3. Safe	Good use of surgical tools	3. Good	Controlled and effective movements	3. Good	No injuries	3. Good	Good placement
	4. Expert	Expert use of surgical tools	4. Expert	Perfect procedure	4. Expert	Correct dissection and port placement	4. Expert	Perfect autonomous Result w/o any help
	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable	X. U/E	Invaluable

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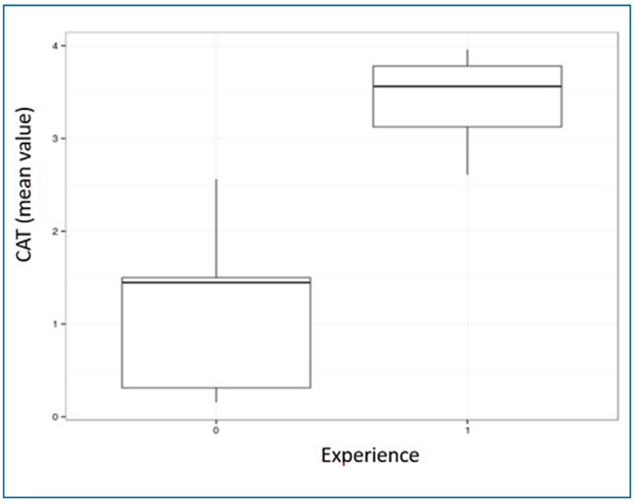

Figure 1. The mean value of the CAT, ± SD error bars in function of degree of experience (0 = junior status or 1 = senior status).

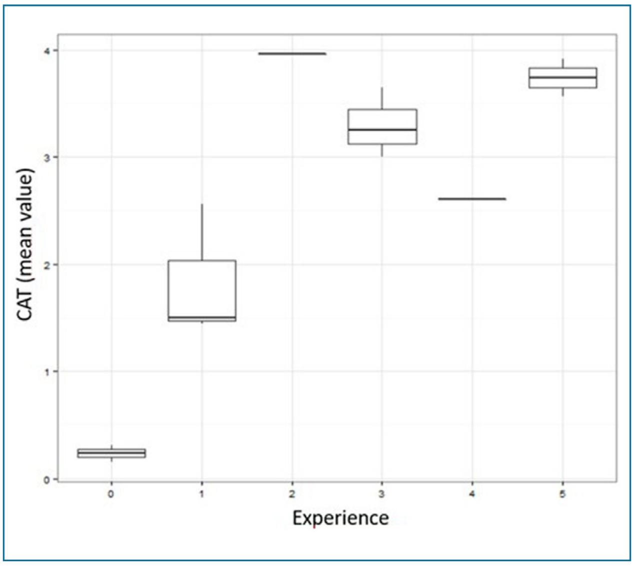

Figure 2. CAT scores in function of surgical experience trainees.

categorical variables. Only univariate analyses were performed.

Results

The procedures were performed by 12 different candidates (Table 2). Seven senior trainees completed 43 procedures, and 5 junior trainees completed 28 procedures. There was no significant difference between the average number of procedures performed by senior and junior trainees (Mann-Whitney U test, $P = 0.62$). Senior trainees had more surgical experience than junior trainees ($P < 0.005$). Patient demographics and characteristics are presented in Table 3, there were no significant differences between the two groups. The mean CAT score was significantly higher in the senior group than in the junior group (Fig. 1), with a mean of 3.41 (2.9—3.93) versus 1.43 (0.78—2.07), respectively (Fig. 2). Moreover, the years of training significantly influenced the CAT score ($P = 0.007$), respectively. Senior candidates were significantly more autonomous compared to junior candidates ($P = 0.003$). The CAT mean scores were higher for the independent trainees than the others trainees: 3.5 (2.96—4.04) versus 2.05 (1.57—2.53), respectively ($P < 0.01$). A threshold CAT score was determined using the ROC method to ascertain when a trainee needs additional supervision (Fig. 3). When the score was above 3.3, the trainee was considered to be autonomous with a sensitivity of 98.5% and a specificity of 90.1%. CAT scores followed a learning curve smoothly and remained influenced by the candidates' experience (Fig. 4).

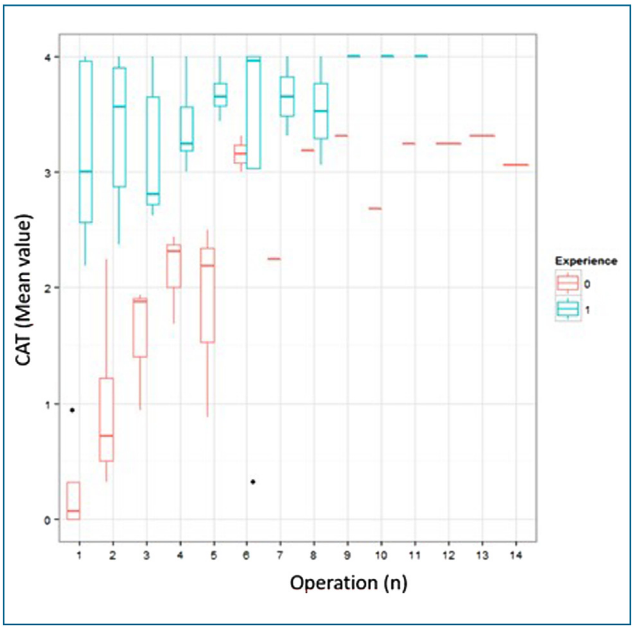

Figure 3. CAT scores' influence by number of procedures.

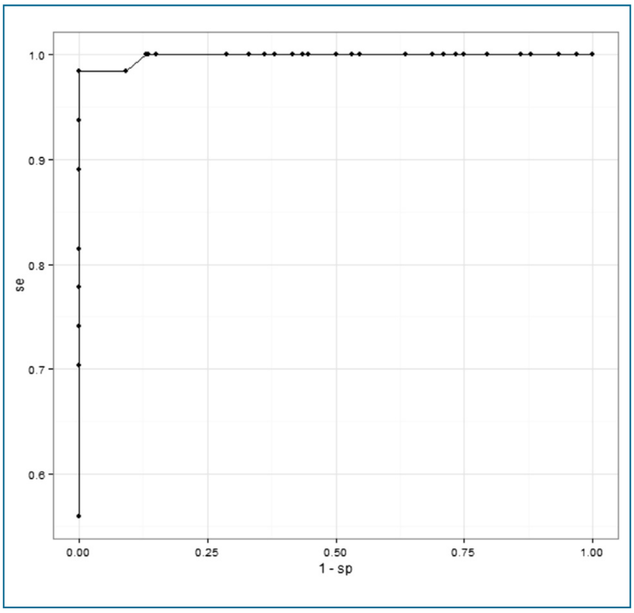

Figure 4. Receiver Operating Characteristic curve of the modified competency assessment tool.

Discussion

This study assessed the CAT ability to evaluate surgery trainees. The CAT allows for the objective evaluation of trainee's performance using a standardised procedure, with a clear cut off value for the average number of procedures required to achieve expertise in the technique.

Table 2 Demography of candidates.

Candidate identity	A	B	C	D	E	F	G	H	I	J	K	L
Experience (years)	3	0	2	3	1	4	0	3	5	5	0	0
Junior (J)—Senior (S)	S	J	S	S	J	S	J	S	S	S	J	J
Procedures (*n*)	6	2	3	11	5	4	1	3	10	6	6	14

Table 3 Patient demographics and characteristics of surgical procedures and their distribution.

Mean (CI 95%)	Juniors	Seniors	*P*
Age (years)	55.9 (50.4—61.4)	57.8 (53.3—62.2)	0.62
Sex ratio (Male/Female)	0.7 (0.4—0.9)	0.5 (0.3—0.7)	0.28
ASA score	2.3 (2—2.6)	2.4 (2.2—2.7)	0.42
BMI (kg/m^2)	25 (22.3—27.1)	25.1 (24.1—27.4)	0.6
Difficult ratio of surgery	0.9 (0.7—0.9)	0.8 (0.6—0.9)	0.36

The CAT model was successfully adapted to the insertion of implantable venous access devices, which supports the application of this method to the evaluation of other procedures. Analysis of the results showed that the demographics of the operated patients and the number of interventions evaluated in the comparative applicant groups did not differ significantly. Moreover, the mean CAT scores obtained by experienced candidates were higher than those obtained by junior candidates, which was as expected, reassuring and served to further supporting the use of the CAT as an effective assessment tool. Many assessment tools currently exist. Some models are applicable to cadavers or animals, others on simulators and finally some are suited for use in the operating room. Those tools were initially developed for the laboratory studies and, as such, were not suitable for clinical practice. They were mostly adapted for a single, specific procedure to score specialized skills and technical abilities [4,8,9]. They were applied to simulators by measuring generic skills in laparoscopic and robotic surgery and displayed shorter learning curves but are insufficient for open surgery [4,6,9,10]. Meanwhile, some authors proposed a rating scale that considers only the stages of an operation, as proposed by Eubanks OBJECTIVES BOSATS [2,10]. To date, there are many models that meet the general standards of competence and surgical dexterity of the OSATS with the ability to be adapted to multiple types of interventions [1,4,11,12].

The CAT has two major advantages compared to the aforementioned tools. It represents a combination of specific criteria to measure technical competence and surgical precision. This tool is well suited for adaptation to other surgical interventions [6]. This type of tool is useful to objectively assess the candidate's base level; their progression and improvement can be evaluated through both an analysis of their strengths and weaknesses during a surgical procedure [6,8]. Several studies are underway in our hospital to validate similar models for other types of surgeries.

The main limitation of this study is the small number of candidates and the lack of validation using other basics procedures. Future studies will include a larger sample population and additional surgical procedures (e.g., cholecystectomy, appendectomy).

Conclusions

Applying the CAT specifically to the insertion of implantable venous access devices proved that it was efficient for the assessment of the technical skills and progress of young surgical trainees.

We believe this tool is useful in tailoring the surgical training according to the progress of each candidate.

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Disclosure of interest

The authors declare that they have no competing interest.

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