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ORIGINAL SCIENTIFIC REPORT

Laparoscopic Liver Surgery Training Course on Thiel-Embalmed Human Cadavers: Program Evaluation, Trainer's Long-Term Feedback and Steps Forward

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Abstract

Objectives The purpose of this study was to evaluate the feedback of participants upon laparoscopic liver surgery (LLS) course on Thiel-embalmed human bodies.

Methods From 2010 to 2017, ten LLS masterclasses have been organized by the Department of Hepatobiliary Surgery at Ghent University Hospital. A 23-question anonymous survey was electronically sent to 119 participants between November 2017 and January 2018, exploring their characteristics and asking for evaluation of the course. The obstacles for implementing LLS in their centers have been assessed.

Results Sixty-four surgeons (53.8%) responded to the survey; 42 (65.6%) were employed at a university hospital; and 39 (60.9%) were in the first decade of their practice as a consultant surgeon. Forty-three (67.2%) surgeons reported an increased percentage of LLS cases afterward. Training on Thiel cadavers was considered superior (49.2%) to other training options including proctoring in the operating room (34.9%), virtual reality (6.3%), video training (4.8%) and practicing on pigs (4.8%). Obstacles identified contained inadequate training, patient's referral pattern, financial issues, lack of dedicated surgical team and time constrains.

Conclusions This survey revealed that a structured short-time program incorporating interactive discussion, live operations and hands-on training on human bodies under proctorship may enhance efficient training in laparoscopic liver surgery. In a step forward for upcoming courses, the importance of team building has to be addressed.

Introduction

Laparoscopic liver surgery (LLS) has been progressively developed and gained worldwide acceptance during the past decade [1]. Although its feasibility is described and well documented, implementation of this technique is still limited to referral centers specialized in liver surgery [2, 3]. However, considering the laparoscopic approach as a standard of practice for minor liver resection and safe and feasible for major hepatectomies in experts' hands [4, 5], there is a strong desire between hepatobiliary surgeons to enhance their techniques in this era [6].

LLS requires delicate skills in both liver surgery and laparoscopic surgery, and some experts believe that only surgeons who do both advanced laparoscopic procedures

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and liver surgeries during daily practice should perform LLS [7]. Although a steep learning curve exists for LLS, the postoperative morbidity should be minimized by stepwise progression in skills [8]. In contrast with pioneers of LLS, currently, surgeons have an opportunity to reduce their learning curve through specific training [9]. However, few studies in the literature evaluated the educational value of LLS training programs [10–16]. Recently, in the Southampton meeting held with the aim of validating guidelines for LLS, the lack of evidence-based studies focusing on education has been emphasized [5].

The aim of this study was to evaluate participants' feedback after joining an intensive hands-on LLS training course and moreover using their feedback to improve the course and to identify the obstacles to implement and spread LLS.

Materials and methods

Course design

Intensive Laparoscopic Liver Surgery Masterclasses have been organized at Ghent University Hospital since 2010. The course is intended for certified general surgeons with a special interest in hepatobiliary and laparoscopic surgery.

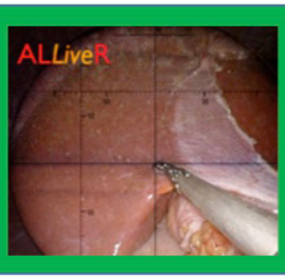
During the first day, state of art lectures, technical tips and different topics in liver surgery are taught and debated. Live streaming interventions are planned and discussed interactively in the boardroom. Additionally, a video session is carefully prepared to show different approaches to the liver for different indications. On the second day, the participants could develop their skills during a hands-on training on Thiel-embalmed human bodies at the Center for Training and Research in Anatomical Sciences (CETRAS) of Ghent University under the proctorship of international experts. This center is part of a skills laboratory that is accredited by the Network of Accredited Skills Centers in Europe (NASCE), a joint committee of the "*Union Européenne des Médecins Spécialistes*" (UEMS). The hands-on session is organized as a full one-day training, and one to two bodies are selected for each training station. The program starts with a lecture on the Thiel body preparation technique, followed by interactive lectures on laparoscopic positioning for liver surgery and introduction to surgical devices which are used during LLS. The procedures are explained step-by-step, and the participants have to reproduce the steps under the guidance of experts. The organizing committee considers one body per participant, and the trainees are divided into groups of two surgeons under supervision of one expert. They practice simultaneously as one aids the other. The training program is based on hilar approach. In one body they perform left lateral and right hepatectomy, and in the other one, they practice left hepatectomy. A laparoscopic ultrasonography probe is available in all the stations, and the participants can use it during the training. However, due to major artefacts and the presence of air bubbles, the images are difficult to interpret comparing to the clinical setting (i.e., identification of the hepatic veins as main landmarks). The UEMS endorsement and continuous medical education credits upon a feedback report of the participants of each masterclass have been provided. In order to evolve this course from "point in time" to lifelong learning resource, a specific website for participant with free access to videos and lectures is kept updated and enriched every year.

Study design

This study was performed based on a qualitative questionnaire and approved by the Ethics Committee of Ghent University Hospital (IRB Approval No. B670201836650). The survey was designed by the scientific committee of the courses, exclusively to evaluate the feedback of the participants. This methodology corresponds to the first level (out of 4) of the Kirkpatrick model for training evaluation and describes the participant's reaction to a training program [17]. Between November 2017 and January 2018, all participants were invited via email to complete a survey to evaluate their experience with the course. The whole survey was available on an online survey platform, utilizing the SurveyMonkey®, and only accessible for invitees. Each participant could answer the questions once, and it was not possible to submit incomplete surveys. To obtain truthful answers from responders and to eliminate author bias during data analysis, the survey was completely anonymous and the participants were assured in the invitation letter that those investigators would be blinded to subject identity. A deadline of one month was considered for participants to fulfill the survey, and a reminder email was sent afterward. Their evaluation of the course and feedback were then analyzed.

Survey design

The survey included a total of 23 questions concerning three main subjects: (1) profile of participants; (2) the scope of the practice; and (3) their feedback on the aims of the masterclasses (Fig. 1). In the profile section, duration of their practice as consultant surgeon and type of medical center were collected; in the practice section, data on the LLS volume, type of LLS and obstacles to implement LLS in their centers were assessed. The third section investigated the feedback of participants about the quality of the course and the value of training on Thiel bodies. Eventually, to attain the best method in speeding up the learning



Survey on ALLIVER Masterclasses

(Advanced Laparoscopic LIVER surgery)

Profile of Participant:

Q1: Which edition of ALLIVER Masterclasses did you attend?

Q2: How did you know about ALLIVER Masterclasses?

Q3: How long have you been practicing as surgeon before attending the ALLIVER Masterclass?

Q4: In which kind of medical center are you working?

Scope of Practice:

Q5: Did you already perform laparoscopic liver procedures when you attended the ALLIVER Masterclass?

Q6: When did you perform your first laparoscopic liver resection? Please specify the year.

Q7: How many major (3 or more segments) laparoscopic resections have you performed?

Q8: How many liver surgery procedures are performed annually in your department?

Q9: How many laparoscopic liver resections are performed annually in your department?

Q10: What percentage of liver surgical procedures at your department is currently being performed laparoscopically?

Q11: Are there obstacles to implement laparoscopic liver surgery in your center? (Multiple answers possible)

Q12: Which kind of upper GI surgery do you routinely perform laparoscopically? (Multiple answers possible)

Q13: What are the indications for your routine laparoscopic approach? (Multiple answers possible)

Q14: What are the contraindications for the laparoscopic liver approach in your opinion? (Multiple answers possible)

Q15: Do you believe the oncological outcomes of the laparoscopic approach is comparable to open surgery? (Multiple answers possible)

Q16: How many HPB surgeons are working in your department?

Q17: How many surgeons in your department perform laparoscopic liver surgery? Please specify.

Participant Feedback:

Q18: ALLIVER Masterclass attendance was useful considering? (Multiple answers possible)

Q19: What was the most interesting feature of the ALLIVER Masterclass you have attended?

Q20: What is your opinion about the training on Thiel bodies?

Q21: What is, according to you, the best option for training laparoscopic liver surgery?

Q22: Has the percentage of your laparoscopic liver surgery cases increased after the ALLIVER course?

Q23: Would you recommend others to attend ALLIVER Masterclasses?

Fig. 1 Questionnaire administered to participants to qualitatively evaluate the course

curve of LLS, their point of view on this topic was requested.

Results

Characteristics of participants and response rate

Over 8 years, a total of 119 surgeons from 29 countries attended the masterclasses. Sixty-four (53.8%) surgeons completed the survey, of which 39 (60.9%) were in their first decade of practice as consultants, 23 (35.9%) were in the second decade of their career and two (3.2%) were in the third decade of practice. Forty-two (65.6%) participants were employed at a university hospital, 11 (17.2%) at a private hospital, 7 (10.9%) at a regional public hospital and 4 (6.2%) at a district public hospital.

Scope of practice

The participants reported annual quantity of LLS in their department as follows: 22 (34.9%) less than 10, 33 (52.4%) between 11 and 50 and eight (12.7%) more than 50 operations. The proportion of LLS in their centers is delineated in Table 1.

Eleven (17.2%) surgeons did not perform LLS before attending the masterclass. Thirty-three (51.6%) performed between 1 and 10, 16 (25%) between 10 and 50 and four (6.25%) surgeons performed more than 50 LLS. The potential obstacles to implement LLS in their centers are summarized in Table 2.

Evaluation of the masterclass

Thirty-one participants (49.2%) believed that a human anatomical laboratory offers the best condition to train LLS. The other useful options were proctoring in the operating room (34.9%), virtual reality training (6.35%), video training (4.8%) and anatomical facility laboratory on pigs (4.8%). Twenty-six (42.6%) participants scored Thiel bodies' usefulness for training as very helpful, and 18 (29.5%) found it helpful. Ten (16.4%) surgeons thought some aspects can be improved, and seven (11.5%) participants considered practicing on Thiel bodies as not helpful. The latter group had already performed LLS before attending the course, and among them six were in the second decade of their career and one had 5–10 years of practice as surgeon. All surgeons found the course useful in terms of learning tips and tricks for their practice, consolidation in technique, learning about perioperative care and indications for surgeries (Table 3). Participants' opinions on the most interesting feature of the attended masterclass are summarized in Table 4. After participating in the course, 43 (67.2%) surgeons reported increasing in performance of LLS cases. Moreover, they all (100%) would recommend it to their colleagues.

Table 1 Number of LLS performed annually in the participant's center

Number of LLS	Responses (%)
< 10	22 (34.92%)
11–25	19 (30.16%)
26–50	14 (22.22%)
51–75	7 (11.11%)
> 75	1 (1.59%)

Table 2 Obstacles to implement LLS in the participant's center (multiple answers were possible)

Obstacles to perform LLS	Responses (%)
Financial issues	19 (29.69%)
Specific training in laparoscopic surgery	19 (29.69%)
Lack of dedicated surgical team	17 (26.56%)
Topology of patient referral	20 (31.25%)
Lack of scheduled extra time	11 (17.19%)
There are no obstacles	18 (28.13%)

Discussion

Laparoscopic liver surgery has a steep learning curve and safe implementation of it requires stepwise training [8, 9]. To overcome the learning curve, for laparoscopic minor hepatectomy approximately 50 procedures are recommended. After reaching competency in minor hepatectomy, ranges between 20 and 60 procedures have been suggested for learning curve in laparoscopic major hepatectomy [2, 7, 8, 18, 19]. However, these numbers represent the difficulties which pioneering surgeons and centers were confronted with in implementing a new technique while a low rate of morbidity is maintained. As such, the learning curve in LLS could be dramatically reduced with specific training and increased exposure of trainees to LLS [9]. The Southampton consensus guideline recommends fellowships in high-volume centers, proctored programs and courses to facilitate training [5]. Nevertheless, the average number of hepatic resections performed by postgraduates at the completion of their general surgery training is estimated to be five cases (range 0–20) [20]. Furthermore, an international survey on minimally invasive training in registered standard hepatobiliary fellowship programs revealed that

Table 3 Participants' opinion on the useful features of the attended masterclass (multiple answers were possible)

Useful feature of the course	Responses (%)
Learning tips and tricks	61 (95.31%)
Consolidation in technique	25 (39.06%)
Learning perioperative care	18 (28.13%)
Reconsider the indications for LLS	6 (9.38%)
It was not helpful	0 (0%)

Table 4 Participants' opinion on the most interesting feature of the attended masterclass

Most interesting feature of the course	Responses (%)
Live streaming operations	12 (18.75%)
Expert presentations and videos	10 (15.63%)
Proctorship during hands-on course	7 (10.94%)
Interactions with experts	14 (21.88%)
The overall program	21 (32.81%)

fellows performed on average nine LLS yearly, which is obviously far too less to meet today's high-quality practice needs [21]. This course represents an attempt in supplementing the lack of adequate training, and the intention was to make it as comprehensive as possible in terms of basic requirements.

The masterclasses organized during the past years showed that surgeons' interest in acquiring LLS expertise is a trending topic. The majority (60.9%) of participants were in their first decade of practice, and most of them (68.7%) had performed less than ten LLSs before attending the masterclasses. This reveals that many surgeons very early in their professional practice are looking for training courses to accelerate learning curve progress.

The core of this program included theoretical courses on basic elements to start laparoscopic liver surgery together with tips and tricks and live surgeries performed by international experts. Moreover, the participants had the opportunity to practice on Thiel human bodies that simulated real cases.

The utilization of training models to simulate complex laparoscopic liver procedures has been poorly studied so far [22]. However, there are a few studies on basic training in LLS which use ex vivo training models resembling liver tissue. Strickland et al. developed an augmented reality simulator for laparoscopic liver resection training which could familiarize junior surgeons with equipment and basic techniques in LLS. They have also used lamb livers for practicing laparoscopic suturing on fragile liver tissue [10]. Others reperfused lamb livers to become competent in advanced laparoscopic suturing. Although hemostatic suturing techniques are essential for safe LLS, technically challenging liver surgery requires more advanced skills [11]. Living animals and cadavers are probably the closest to reality. Pigs are commonly used in training and offer tactile feedback, facilitating the acquisition of fundamental skills. However, the anatomy of pig livers differs from humans. In addition, a specialized anesthesiology team is often needed to ensure stable hemodynamic conditions [12]. Sheep have also been reported as a suitable animal model for LLS training. Even though the anatomy has been found close to human liver, the number of investigated livers is too small to make robust conclusions [13]. Human cadavers, however, have identical anatomical conditions as patients and enable lifelike surgery. Their use as a laparoscopic training model has already been reported in several studies [22–24]. Of note, the main drawback of formalin-fixed cadavers is tissue rigidity. Additionally, formalin bodies are malodorous, the anatomic structures do not maintain their natural color, and it is difficult to achieve a pneumoperitoneum. In contrast, Thiel bodies are soft and flexible and maintain their natural color. These corpses remain more similar to in vivo conditions without releasing harmful substances into the environment [23–27]. Furthermore, vascular perfusion of Thiel-embalmed cadaveric tissues with colored solutions for endovascular procedures and flap raising education has been described [28, 29]. Also, in a training model for trauma surgeons, circulation in cadavers' major vessels has educational value [30]. Vascular reperfusion could be interesting in liver surgery training as well where major bleeding is a prominent technical concern. Researchers have established vascular reperfusion in isolated Thiel-embalmed human liver, which may augment the educational quality of upcoming masterclasses [31]. Considering the benefits of soft cadavers for education, there are few reports in the literature which assess their efficacy in LLS [14–16]. In the largest study that evaluated 32 participants' feedback, their average rating of the overall usefulness of fresh frozen human cadavers for LLS training was very good [15]. Not only the current survey confirmed these results in a larger scale, but also revealed that most participants found the Thiel bodies as the most realistic tool to practice and enhance their competences. They considered Thiel bodies significantly superior to pig models (49.2% vs. 4.8%) and even more useful than training under proctorship in the operating room (34.9%). Although seven participants presumed that practicing on Thiel bodies is not useful, they had previous experience with LLS before joining the courses. Nevertheless, they found the courses useful in terms of learning tips and tricks, interacting with experts and watching live streaming operations in experienced hands. It seems that practicing on Thiel bodies should be reserved as the last step of training before performing the LLS on the patient.

However, after acquainting the technical abilities to perform LLS, training should be kept updated.

This survey indicates that the main obstacles in developing LLS are the referral system, the lack of specific LLS training, financial issues and limited scheduled time. In interpreting these results, we confirm the already stated consensuses that LLS appears to be confined to highly specialized centers where patients are regularly referred [4, 5]. There is a need of a tailored system in which finances are specifically targeted and a dedicated team is employed. For debating how to implement the LLS program from the beginning with intention to increase collective expertise, a special session focusing on team building and service line make up for future courses seems to be essential.

The low response rate (53.8%) from surgeons with different experience and educational background is a limitation of the study. In addition, there is a possible selection bias as surgeons with good memories of the masterclass were more likely to respond to the survey which could skew the data into the extreme direction. Finally, bear in mind that the survey is a subjective method to assess the quality of training. The goal of every surgical training model is to shorten the surgeon's learning curve and to improve the patient outcome after surgery. Therefore, before indicating a training program as a useful model, the transfer of the learned skills to the operation room should be assessed using validated objective assessments tools, and ideally the impact of this progress in skills on patient's outcome should be proved.

In conclusion, a specialized masterclass that integrates interactive theory, live and cadaver surgery offers an effective solution to implement the training in LLS and eventually promotes its distribution. Practicing on Thiel human bodies seems to be a promising option among all available educational models and could be improved by means of using perfused bodies. The importance of team building has to be emphasized for future courses.

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Compliance with Ethical Standards

Conflict of interest The authors declared that they have no conflict of interest.

Ethical approval The study was approved by the local Ethics Committee (IRB Approval No. B670201836650).

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