Surg Endosc (1999) 13: 118–122

Surgical Endoscopy
Ultrasound and
Interventional Techniques

Effectiveness of a hands-on training course for laparoscopic spine surgery in a porcine model

A. Olinger,[1] G. Pistorius,[2] W. Lindemann,[2] B. Vollmar,[3] U. Hildebrandt,[2] M. D. Menger[3]

[1] Department of Trauma Surgery, University of Saarland, D-66421 Homburg/Saar, Germany
[2] Department of General Surgery, University of Saarland, D-66421 Homburg/Saar, Germany
[3] Institute for Clinical and Experimental Surgery, University of Saarland, D-66421 Homburg/Saar, Germany

Received: 30 July 1997/Accepted: 26 March 1998

Abstract
Background: Although it is widely proposed that surgeons, before introducing a novel laparoscopic technique in man, should practice in an appropriate animal model for acquisition of the necessary technical skills, the effectiveness of those hands-on training courses are rarely documented.
Methods: In 1995 we have organized eight hands-on training courses for laparoscopic anterior interbody spine fusion in an *in vivo* porcine model. A total of 72 colleagues from 50 different centers of 12 countries participated, including orthopedic, trauma, visceral, neuro-, and vascular surgeons. Quality and effectiveness of the course were evaluated by a questionnaire after a 1.5- to 2.5-year period.
Results: During this time, 42.2% of the participating centers had applied the new technique successfully in man. Centers which participated in the course with a team that included a skilled laparoscopic surgeon and an orthopedic or trauma surgeon introduced the technique more frequently to clinical practice (57.9%) than those represented by only one participant (30.8%). Moreover, there was a tendency toward a more frequent introduction of the technique to clinical practice in centers associated with university hospitals (57.1% vs. 29.2%), indicating the requirement of a particular infrastructure for this complex interdisciplinary procedure. Almost all participants (98.3%) agreed that for novel surgical techniques requiring advanced technical skills, there should first be training in a large animal model before the technique is applied in man.
Conclusions: Complex laparoscopic procedures (i.e., laparoscopic spine surgery) can be successfully learned by *in vivo* hands-on training courses. We propose that for refinements and modifications of the technique (e.g., the lumboscopic approach), there should also first be training in a large animal model before these are applied in man.

Key words: Hands-on training course — Minimal invasive surgery — Laparoscopic anterior interbody spine fusion — Porcine model

Correspondence to: M. D. Menger

Anterior lumbar interbody spine fusion for the treatment of various degenerative or postoperative lesions associated with low back pain is known to induce a considerable surgical trauma with high postoperative morbidity, and occasionally, unacceptably high complication rates [14]. The use of a laparoscopic approach may significantly reduce the extent of the surgical trauma, and thus, postoperative morbidity. However, such an approach requires sophisticated technical skills for the successful performance of both the laparoscopic and orthopedic parts of the operation.

Large animal models have been suggested for the surgeon's use in developing the technical skills necessary to perform those special types of laparoscopic interventions [6]. On the basis of this idea, we have introduced a porcine model for training in laparoscopic spine fusion, and we reported our first experience in this journal about 2 years ago [10]. At that time, we have also organized a number of training courses in this model to teach our experience to both laparoscopic and orthopedic surgeons.

Although it is widely proposed that surgeons, before introducing a novel laparoscopic technique in man, should practice in an appropriate animal model for acquisition of the necessary technical skills [2, 4, 6, 10, 21], the effectiveness of such hands-on training courses are rarely documented. Thus, we decided to analyze the efficiency of our training courses on laparoscopic spine surgery, performed in 1995. Participants were not asked directly for evaluation during the course, but were interviewed by a questionnaire after almost two years. It was thought that this would avoid bias in assessment of the course's value due to possible initial enthusiasm about the new technique, and, additionally, allow a report about whether the new technique was in fact transferred to clinical practice.

1. your affiliation is

- orthopedic surgery
- trauma surgery
- neurosurgery
- visceral surgery
- vascular surgery

2. you have participated at the training course

- alone
- accompanied by a visceral surgeon
- accompanied by an orthopedic surgeon
- nurse

3. if you was accompanied by a colleague, do you feel that this was of benefit/advantage ?

- yes / no

if you was not accompanied by a colleague, do you feel that this was a disadvantage ?

- yes / no

4. your overall assessment of the value and the quality of the training course is

- excellent / good / moderate / bad

5. based on your experience with the training course, did you perform laparoscopic spine surgery in man ?

- yes / no

6. if you have performed laparoscopic spine surgery in man, do you feel that the training course was helpful for the first application in man ?

- yes / no

if you did not have performed laparoscopic spine surgery in man up to now, do you plan to do this in future ?

- yes / no

7. if a new technique in surgery has to be introduced, would you again participate at a training course in pigs before applying the new technique in man ?

- yes / no

Fig. 1. Questionnaire sent to the participants 1.5 to 2.5 years after they attended the training course for laparoscopic interbody spine fusion.

Materials and methods

From January to December 1995, a total of eight training courses for laparoscopic anterior interbody spine fusion in pigs were organized at the Institute for Clinical and Experimental Surgery of the University of Saarland in collaboration with the Departments of General and Trauma Surgery. The supervisors were highly experienced in both the laparoscopic and orthopedic surgical procedures. Before setting up the courses, the supervisors trained themselves by establishing the model and modifying the instrumentation [10].

For medical centers, wanting to participate in the courses, it was suggested that the staff do this as a team including both an advanced laparascopic surgeon and an orthopedic or trauma surgeon. We also suggested the inclusion of a nurse experienced in instrumentation of orthopedic surgery.

During a 2-day period, the courses included a theoretical and a practical part. The theoretical part consisted of review lectures and discussions on the general background of the procedure, selection criteria for the indications, and knowledge about the biomechanical properties of the fusion implants. In addition, an introduction to the instrumentation material was given. The practical part included the use of a laparoscopy trainer, *ex situ* instrumentation of the calf spine, and several *in vivo* instrumentations in the pig. The work with the laparoscopy trainer aimed at training with laparoscopic instruments and camera guidance, and included simple exercises such as cutting and hand-suturing. This practical training was of particular importance for those orthopedic surgeons not familiar with laparoscopic techniques. *Ex situ* instrumentation of the calf spine (with the laparoscopy trainer) was intended to introduce the instrumentation procedure practically to the participants before their *in vivo* exercise. Finally, laparoscopic anterior interbody spine fusion was performed *in vivo* in the porcine model, including complete intervention similar to that performed in man.

For *in vivo* training two operations were performed in parallel and repeated a total of three times. At each operation table two teams worked together, changing the responsibilities for operating and assisting, so that all of the participants finally had performed the entire procedure at least once in each position.

The questionnaire was sent out to each participant in March and April 1997, and a second time in May and June 1997 to those who had not responded. Thus, there was 1.5- to 2.5-year interval between participation in the course and final assessment. To receive an appropriate response rate, the questionnaire was designed to be as simple and short as possible, including a total of only seven questions (Fig. 1). These included questions about whether the participants represented their center alone or if they were accompanied by a colleague (visceral, orthopedic, or trauma surgeon) or a

Table 1. Differentiated analysis of the comments of participants attending the course as a team or alone (single participant) on whether it was or would have been an advantage to participate as a team

	Team *n* (%)	Single participant *n* (%)
Number of participants	32	26
Advantage of participation as team	30 (93.8)	14 (53.8)
No advantage of participation as team	2 (6.2)	12 (46.2)

$p < 0.01$ (team vs. single participant).

nurse. Participants accompanied by a colleague were asked whether they felt that this was of benefit or not. Those not accompanied by a colleague were asked to give a statement on whether they felt this was a disadvantage or not. The subjective overall assessment of the value and the quality of the course had to be categorized as ''excellent,'' ''good,'' ''moderate,'' or ''bad.'' In addition, participants had to indicate whether they had performed laparoscopic spine surgery in man at their home center during the 1.5- to 2.5-year period, and if so, whether they feel that the training course was helpful for the introduction of the technique to clinical practice. Those participants who had not performed laparoscopic spine surgery in man up to the time of evaluation were asked whether they plan to do this in future. Finally, all participants had to indicate, whether, in case a new surgical technique had to be introduced to clinical practice, they would again participate in a training course using a large animal model before applying the technique in man.

Data are given in percentages of all participants or centers, respectively, that participated or responded. Comparison between subgroups was performed by the Fisher exact test using the software package SigmaStat (Jandel Corporation, San Rafael, CA).

Results

A total of 72 surgeons from 50 different centers participated in the eight training courses. Twenty participants (27.8%) were from German medical centers, whereas the majority of participants (72.2%) were from centers of other countries, including the United Kingdom, Sweden, the Netherlands, Belgium, Luxemburg, France, Switzerland, Greece, Israel, Japan, and the United States. Forty-eight percent of the participating centers (24 of 50) were associated with an university hospital.

Nineteen centers were represented by a team, which in general consisted of two participants (i.e., a visceral surgeon experienced in laparoscopic surgery accompanied by an orthopedic or trauma surgeon). Three teams additionally included a nurse experienced in orthopedic instrumentation. Thirty-one centers were represented by only one participant. The special fields of the participants included visceral, orthopedic, trauma, neuro-, and vascular surgery.

The questionnaire was answered by 58 participants (80.6%) from 45 of the 50 centers represented (90%). Most of the participants, who were accompanied by a colleague, felt that participating as a team was an advantage, whereas only two reported no perceived benefit (Table 1). Strikingly, only about half of those participants who represented their centers alone felt that it would have been an advantage to participate as a team, whereas the others reported that participating in the course alone was no disadvantage ($p < 0.01$; Table 1).

The overall assessment of the value and the quality of the training courses given by the participants after the 1.5- to 2.5-year period was mainly ''excellent'' or ''good'' (Fig. 2). Five participants found the quality of the course only

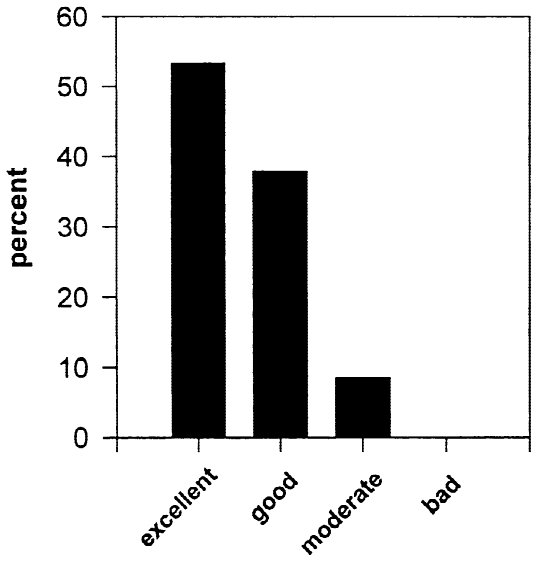

Fig. 2. Participants' subjective overall assessment on the value and the quality of the training courses for laparoscopic spine surgery ($n = 58$).

''moderate,'' whereas none evaluated it as ''bad.'' By numeric evaluation (1 = excellent, 2 = good, 3 = moderate, 4 = bad) the mean assessment was 1.53. Differentiated analysis revealed that potential difficulties in teaching and/or understanding due to foreign language did not play a significant role in the subjective assessment of the quality of the courses because the estimate of German participants was even worse (1.70) than that of participants from other countries (1.45).

Although not all participants responded to the questionnaire, we received information on whether the technique was transferred to clinical practice from 45 of the 50 participating centers. A total of 19 centers (42.2%) reported that the technique of laparoscopic anterior interbody spine fusion was applied in man during the 1.5- to 2.5-year period. In addition, participants of one center had introduced the technique in clinical practice thoracoscopically, whereas another group had performed the transabdominal approach using a minilaparotomy. In three additional centers anterior interbody fusion by the hollow-threaded titanium cages was introduced by open surgery, but not laparoscopically.

Differentiated analysis between those centers represented by a team at the course and those represented by only one participant revealed that teams introduced the technique to clinical practice more frequently (Table 2). Statistical analysis, however, did not prove this difference significant ($p = 0.126$) at a $p < 0.05$ level, which is probably due to the relatively small number of centers included in our study. Analysis in terms of association to university hospitals demonstrated a tendency toward a more frequent application of the technique in man at centers linked to the university than at those not associated with university hospitals ($p = 0.075$; Table 3). This, however, did not result in a different subjective estimation of the value and quality of the courses. The estimate of participants applying the technique in man was 1.67 ($n = 24$), whereas that of participants who did not introduce the technique to clinical practice was 1.44 ($n = 34$).

In evaluating whether the training course with pigs was

Table 2. Differentiated analysis between centers represented by a team at the course and those represented by only one participant in relation to whether the technique of laparoscopic spine surgery was introduced in man

	Team *n* (%)	Single participant *n* (%)
Number of centers	19	26
Technique introduced in man	11 (57.9)	8 (30.8)
Technique not introduced in man	8 (42.1)	18 (69.2)

$p = 0.126$ (team vs. single participant).

Table 3. Differentiated analysis between centers linked to the university and those not associated with university hospitals in relation whether the technique of laparoscopic spine surgery was introduced in man

Association	University *n* (%)	Non university *n* (%)
Number of centers	21	24
Technique introduced in man	12 (57.1)	7 (29.2)
Technique not introduced in man	9 (42.9)	17 (70.8)

$p = 0.075$ (university vs. nonuniversity).

helpful for the first application in man, all participants from centers that had applied the technique in man responded positively (i.e., they felt that the course was helpful in introducing the technique to clinical practice). Analysis of the response of participants from those centers that did not introduce the technique to clinical practice during the 1.5- to 2.5-year period revealed that 79.4% (27/34) still intend to use the technique in man, whereas only seven participants (20.6%) had no plans to introduce the laparoscopic spine fusion procedure to clinical practice.

Finally, 57 of the 58 participants (98.3%) responding to the questionnaire indicated that, in case a new technique in surgery had to be introduced to clinical practice, they would again participate at a training course in pigs before applying the new technique in man.

Discussion

The advances in the experience with laparoscopic techniques have led to the recent introduction of laparoscopic spine surgery by several centers, including the procedure of transabdominal anterior interbody fusion [12, 13, 15, 16, 20, 24]. The operative technique, however, is quite complex and requires advanced skills in both laparoscopic and orthopedic surgery. Thus, apart from ourselves, others also used first a porcine model to gain experience with the new technique [20], and most of the groups that have introduced the procedure to clinical practice are in accordance with us by involving, beside the orthopedic surgeon, an experienced laparoscopic surgeon [13, 20].

There is agreement that training courses improve the technical skills necessary to apply novel techniques. There is, however, little documentation of the efficiency of those training courses, in particular concerning the frequency of consequent introduction of the novel techniques to clinical practice. Herein we demonstrate that a complex procedure requiring tremendous skills in both laparoscopic and orthopedic surgery can successfully be learned in an *in vivo* training model, and that in spite of the complexity of the technique (requiring specific infrastructure), more than 40% of the centers that participated in the courses, were able to introduce the technique in man. The fact that all participants who have done the procedure in man commented on the training course as helpful for the first application supports our concept of developing such courses for training in the new techniques. This view is also in accordance with training concepts concerning other sophisticated laparoscopic interventions including laparoscopic gastrectomy [1], adrenalectomy [18], nephrectomy [9], splenectomy [8, 23], pancreatectomy [19, 22], and vascular [3, 5, 7, 11] and biliary surgery [4, 6].

With the knowledge that laparoscopic anterior interbody spine fusion is a complex intervention involving visceral, vascular, and bone preparation and instrumentation procedures, we have suggested to the centers interested in the courses that they should participate as a team including an experienced laparoscopic and an orthopedic or trauma surgeon. Although about 50% of the participants not accompanied by a colleague felt that this was not a disadvantage, the evaluation of the questionnaires showed a tendency toward a more frequent introduction of the technique to clinical practice during the 1.5- to 2.5-year period after course participation by centers represented by a team than by those represented by only one participant. It cannot be concluded whether the more frequent introduction of the technique to clinical practice by teams reflects merely a greater prior commitment to do this type of minimally invasive surgery rather than more effective learning in the courses. However, the observation still supports the concept that a most confident cooperation between laparoscopic and orthopedic surgeons is necessary for a complex intervention such as the laparoscopic anterior interbody spine fusion. The fact that centers associated with university hospitals also more frequently applied the technique in man may be due to the presumably superior infrastructure provided in these central institutions.

The overall assessment on whether a course in a large animal model should be used for training in a novel complex surgical intervention before applying in man revealed that almost all participants responding agreed that they would again exercise the technique in an *in vivo* animal model before introducing it to clinical practice. One participant indicated a preference for using an inanimate (cadaveric) model. However, we feel that atraumatic handling of intraperitoneal organs, achievement of hemostasis, dissection of the retroperitoneum with ligation of individual vessels, and the like are essential skills that can be acquired only in an appropriate *in vivo* model. Our view is supported by others experienced in the development of large animal models as educational tools in a variety of different laparoscopic interventions, including colorectal surgery [2].

In conclusion, we have demonstrated that a complex laparoscopic procedure (i.e., laparoscopic anterior interbody spine fusion) can be successfully learned in an *in vivo* hands-on training course. More than 40% of the centers that participated in the course transferred the technique within a

1.5- to 2.5-year period to clinical practice. We propose that refinements and modifications of the technique, such as the retroperitoneal access, also should first be practiced in a large animal model before being applied in man.

Acknowledgment. We appreciate the excellent secretarial assistance of Mrs. B. Reiland.

References

1. Ablassmaier B, Gellert K, Tanzella U, Müller JM (1996) Laparoscopic Billroth-II gastrectomy. J Laparoendosc Surg 6: 319–324
2. Bohm B, Milsom JW (1994) Animal models as educational tools in laparoscopic colorectal surgery. Surg Endosc 8: 707–713
3. Byrne J, Hallett JW Jr, Kollmorgen CF, Gayari MM, Davies W (1996) Totally laparoscopic aortobifemoral bypass grafting in an experimental model: description of technique with initial surgical results. Ann Vasc Surg 10: 156–165
4. Cameron BH, O'Regan PJ, Anderson DL (1994) A pig model for advanced laparoscopic biliary procedures. Surg Endosc 8: 1423–1424
5. Chen MH, Murphy EA, Levison J, Cohen JR (1996) Laparoscopic aortic replacement in the porcine model: a feasibility study in preparation for laparoscopically assisted abdominal aortic aneurysm repair in humans. J Am Coll Surg 183: 126–132
6. Crist DW, Davoudi MM, Parrino PE, Gadacz TR (1994) An experimental model for laparoscopic common bile duct exploration. Surg Laparosc Endosc 4: 336–339
7. Dion YM, Chin AK, Thompson TA (1995) Experimental laparoscopic aortobifemoral bypass. Surg Endosc 9: 894–897
8. Gossot D, Debiolles H, el Meteini M, Fourquier P, Ghnassia MD, Celerier M, Revillon Y, Chourrout Y (1993) Laparoscopic splenectomy: initial laboratory experience. Endosc Surg Allied Technol 1: 26–28
9. Henkel TO, Potempa DM, Rassweiler J, Frede T, Stock C, Alken P (1994) Experimental studies for clinical standardization of transabdominal laparoscopic nephrectomy. Eur Urol 25: 55–61
10. Hildebrandt U, Pistorius G, Olinger A, Menger MD (1996) First experience with laparoscopic spine fusion in an experimental model in the pig. Surg Endosc 10: 143–146
11. Jones DB, Thompson RW, Soper NJ, Olin JM, Rubin BG (1996) Development and comparison of transperitoneal and retroperitoneal approaches to laparoscopic-assisted aortofemoral bypass in a porcine model. J Vasc Surg 23: 466–471
12. Mahvi DM, Zdeblick DA (1996) A prospective study of laparoscopic spinal fusion: technique and operative complications. Ann Surg 224: 85–90
13. Mathews HH, Evans MT, Molligan HJ, Long BH (1995) Laparoscopic discectomy with anterior lumbar interbody fusion: a preliminary review. Spine 20: 1797–1802
14. Mayer HM (1997) A new microsurgical technique for minimally invasive anterior lumbar interbody fusion. Spine 22: 691–699
15. Olinger A, Hildebrandt U, Pistorius G, Lindemann W, Menger MD (1996) Laparoskopische 2-Etagenfusion der lumbalen Wirbelsäule mit Bagby-and-Kuslich (BAK)-Implantaten. Chirurg 67: 348–350
16. Olsen D, McCord D, Law M (1996) Laparoscopic discectomy with anterior interbody fusion of L5-S1. Surg Endosc 10: 1158–1163
17. Onimus M, Papin M, Gangloff S (1996) Extraperitoneal approach to the lumbar spine with video assistance. Spine 21: 2491–2494
18. Park A, Gagner M (1995) A porcine model for laparoscopic adrenalectomy. Surg Endosc 9: 807–810
19. Pistorius GA, Schuder G, Hildebrandt U, Plusczyk T (1995) Experimental approach to left laparoscopic pancreas resection preserving the spleen. Zentralbl Chir 120: 405–408
20. Regan JJ, McAfee PC, Guyer RD, Aronoff RJ (1996) Laparoscopic fusion of the lumbar spine in a multicenter series of the first 34 consecutive patients. Surg Laparosc Endosc 6: 459–468
21. Schob OM, Day PW, Josloff RK, Zucker KA (1996) An experimental teaching model for laparoscopic choledochjejunostomy. Surg Laparosc Endosc 6: 341–347
22. Soper NJ, Brunt LM, Dunnegan DL, Meininger TA (1994) Laparoscopic distal pancreatectomy in the porcine model. Surg Endosc 8: 57–60
23. Thibault C, Mamazza J, Letourneau R, Poulin E (1992) Laparoscopic splenectomy: operative technique and preliminary report. Surg Laparosc Endosc 2: 248–253
24. Zucherman JF, Zdeblick TA, Bailey SA, Mahvi D, Hsu KY, Kohrs D (1995) Instrumented laparoscopic spinal fusion: preliminary results. Spine 20: 2029–2034