in vivo *36*: 2835-2839 (2022)
doi:10.21873/invivo.13022

Three-dimensional Laparoscopy (3D-LC) *Versus* Minilaparotomy (MC) in Cholecystectomy: A Prospective Randomized Study

MAARET ESKELINEN[1,2], IINA SAIMANEN[1,2], TUOMAS SELANDER[3], JARI KÄRKKÄINEN[1,2], PETRI JUVONEN[1,2], SAMULI ASPINEN[2] and MATTI ESKELINEN[1,2]

[1]Department of Surgery, [2]School of Medicine, and [3]Science Service Center, Kuopio University Hospital (KUH) and University of Eastern Finland (UEF), Kuopio, Finland

Abstract. *Background/Aim: Three-dimensional laparoscopy (3D-Lap) is a recent innovation in surgery. The 3D-Lap is rarely used in cholecystectomy (3D-LC) and there are no prospective studies assessing advantages and disadvantages of 3D-LC versus minilaparotomy (MC) in cholecystectomy. Patients and Methods: This was a prospective clinical study conducted in the Kuopio University Hospital, including 200 patients with symptomatic cholelithiasis who were randomized into 3D-LC (n=112) or MC (n=88) groups. The numeric rating scale (NRS) pain score and number of analgesic doses (NAD) following surgery were documented. Results: Similar low postoperative pain scores were reported in the 3D-LC and MC groups during the first hours following surgery, although the 3D-LC patients reported lower NRS pain score (p<0.05) one hour postoperatively. Interestingly, the 3D-LC patients showed significantly less pain 24 hours following surgery, the mean of NRS of 0-10 score at rest being 1.2 in the 3D-LC group versus 2.2 in the MC group (p<0.001), and the pain at the quick movement/coughing, the mean NRS being 2.9 in the 3D-LC group versus 3.6 in the MC group (p=0.05). Conclusion: The 3D-LC patients reported significantly lower pain scores 24 hours postoperatively than MC patients. However, the patient experience of pain depends on many factors and our results suggest that both 3D-LC and MC are safe and efficient techniques for cholecystectomy.*

Correspondence to: Matti Eskelinen, MD, Department of Surgery and School of Medicine, KUH and UEF, P.O. Box 100, FI-70029 KYS, Kuopio, Finland. Tel: +358 17173311, Fax: +358 17172611, e-mail: matti.eskelinen@kuh.fi

Key Words: Cholelithiasis, 3D laparoscopy, minilaparotomy, NRS pain score, analgesic doses.

Two-dimensional laparoscopic cholecystectomy (2D-LC) is the gold-standard operative technique for the treatment of symptomatic cholelithiasis (1-3). The minilaparotomy cholecystectomy (MC) technique is a feasible and safe option currently in use, because of the simple instrumentation used and reasonable costs (2, 3). Three-dimensional laparoscopy (3D-lap) is the latest development in laparoscopic surgery and has been shown to enhance surgical efficacy, diminish errors, increase spatial awareness, and reduce time to complete surgical tasks in laboratory settings (4, 5). Recently, certain clinical studies investigated whether the advantages of 3D-lap found in laboratory are transferable to the clinical environment (3, 6-8). These studies have presented conflicting results; some report benefits for 3D-lap (6-8), while others did not find advantages of 3D-lap over conventional 2D-lap (3, 9).

The 3D-lap is uncommon in cholecystectomy (3D-LC) and there are no earlier studies assessing 3D-LC *versus* MC in cholecystectomy. The aim of our study was to assess whether the 3D-LC technique could enhance the patient satisfaction with lower pain scale in comparison to the MC procedure.

Patients and Methods

The study was approved by the Ethics Committee of the Kuopio University Hospital, Kuopio, Finland (DNRO 27/02/2013), it was registered in the ClinicalTrials.gov database (ClinicalTrials.gov Identifier: NCT01723540) and was conducted in accordance with the Declaration of Helsinki. The study included 200 patients with cholelithiasis stratified in 3D-LC (n=112) or MC (n=88) groups. The operations were performed by two surgeons at consultant level (PJ operated 20 patients and ME operated 180 patients), and the 3D-LC and MC surgical techniques used were familiar for both surgeons. The Olympus LTF-S300-10-3D laparoscopic HD device with flexible Endoeye flex videoscopes were used for the 3D-Lap

Table I. *Baseline demographic characteristics and surgical data for the minicholecystectomy (MC) and three-dimensional laparoscopy (3D-LC) groups.*

Variable	MC n=88	3D-LC n=112	*p*-Value
Age (years)	54 (16)	52 (13)	0.374
	56 [21-88]	53 [23-88]	
Height (cm)	164 (6)	168 (9)	<0.001
	164 [149-185]	166 [146-193]	
Weight (kg)	77 (16)	81 (15)	0.114
	75 [48-130]	80 [52-152]	
BMI (kg/m^2)	28.9 (5.4)	28.7 (4.8)	0.780
	27.6 [19.0-46.6]	28.0 [20.6-42.3]	
Sex (female/male)	81/7	86/26	0.001
ASA 1/2/3/4	26/48/11/1	49/55/8/0	0.096
Operative time	69 (23)	78 (24)	0.011
(minutes)	64 [34-137]	76 [39-208]	
Time at the operation	121 (25)	133 (27)	0.003
theatre (minutes)	116 [76-204]	128 [81-271]	
Bleeding (ml)	41 (62)	25 (31)	0.036
	20 [4-350]	20 [0-200]	
Length of the skin	64 (18)	104 (25)	<0.001
incisions (cm)	60 [45-135]	101 [55-275]	

Data are mean (standard deviation), median [range] or number of cases. BMI: Body mass index; ASA: American Society of Anesthesiologists physical status score. *t*-test and Fisher's exact test were used.

Table II. *Postoperative pain in the minicholecystectomy (MC) and three-dimensional laparoscopy (3D-LC) groups.*

Variable	MC n=88	3D-LC n=112	*p*-Value
Pain at hospital			
At 1 hour	4.5 (2.3)	3.8 (2.4)	**0.050**
	5 [0-10]	4 [0-9]	
At 2 hours	3.1 (2.2)	2.8 (2.0)	**0.284**
	3 [0-10]	2 [0-8]	
At 3 hours	2.4 (2.1)	2.5 (1.8)	**0.740**
	2 [0-10]	2 [0-8]	
At 4 hours	2.0 (2.1)	2.2 (1.7)	**0.661**
	2 [0-10]	2 [0-7]	
Most pain at hospital	5.0 (1.9)	4.7 (1.9)	0.140
	5 [1-10]	4 [1-9]	
At discharge	1.1 (1.1)	1.2 (1.0)	0.790
	1 [0-5]	1 [0-4]	
Mean pain during	2.7 (1.8)	2.6 (1.3)	0.395
first 8 hours	2.4 [0-10]	2.3 [0-7]	

Pain was assessed with an 11-point numeric rating scale (NRS, 0=no pain, 10=most pain). Data are mean (standard deviation) and median [range]. Linear mixed model *p*-values for group difference between MC and 3D-LC groups are shown in bold. Mann-Whitney *U* and LME tests were used.

procedures (Olympus Medical Systems Corp., Tokyo, Japan). The MC technique protocol is fully described by Harju *et al*. (1). Overall pain was filed on an 11-point numeric rating scale (NRS; 0=no pain; 10=most pain).

Data are presented as means and standard deviations or frequencies and percentages in Table I. In Table II the results of the NRS scores are presented as medians with interquartile range as distributions, right-skewed. Differences in baseline characteristics between 3D-LC and MC groups were tested by the Fisher's exact test and in the case of continuous data, the analysis was performed by the *t*-test. Outcome variables were compared by the Mann-Whitney *U*-test or Fisher's exact test. The linear mixed effect (LME) model was used to test for group differences on repeated measurement outcomes in 3D-LC and MC study groups (10). In LME analysis the mean NRS score values were used. Data were analyzed by the IBM SPSS statistical software (IBM SPSS Statistics for Windows, version 26.0, IBM Corporation, Armonk, NY, USA).

Results

Patient data. In the MC study group, there were 88 patients (81 females and 7 males) *versus* 112 patients in the 3D-LC group (86 females and 26 males) (Figure 1), with a mean age of 54 years *versus* 52 years. There were no significant differences between the MC and 3D-LC study groups in mean age (p=0.374), mean weight (77 and 81, p=0.114), mean body mass index (BMI, 28.9 and 28.7, p=0.780) and American Society of Anesthesiologists physical status score (ASA) score (p=0.096). The operative time and time in the operative room were significantly shorter in MC patients than in 3D-LC patients (69 and 78 min, respectively, p=0.011, and 121 and 133 min, respectively, p=0.003) (Table I), whereas 3D-LC patients had significantly lower value of perioperative bleeding (25 and 41 ml, respectively, p=0.036). Interestingly, the mean length of skin incision was significantly shorter in the MC than in 3D-LC group (64 mm and 104 mm, respectively, p<0.001, Table I).

In-hospital recovery. Similar low NRS scores were observed in the 3D-LC and MC study groups during the first four hours after surgery, although the 3D-LC patients reported significantly lower NRS pain scores (p<0.05) one hour post-operation (Figure 1). There was no significant difference between the two study groups in the 'most postoperative NRS pain score at hospital's variable and the mean NRS pain score during the first hours after surgery (Table II). The incidence of nausea/vomiting was similar in the 3D-LC *versus* MC study groups (25%/9% *vs*. 26%/7%, respectively).

Recovery after discharge. The 3D-LC patients showed significantly less pain 24 hours following surgery, the mean of NRS of 0-10 score at rest being 1.2 in the 3D-LC group *versus* 2.2 in the MC group (p<0.001), and the pain at the quick movement, the mean NRS being 2.9 in the 3D-LC group *versus* 3.6 in the MC group (p=0.05). The 3D-LC patients also reported lower pain score while coughing (p=0.09) and the 3D-

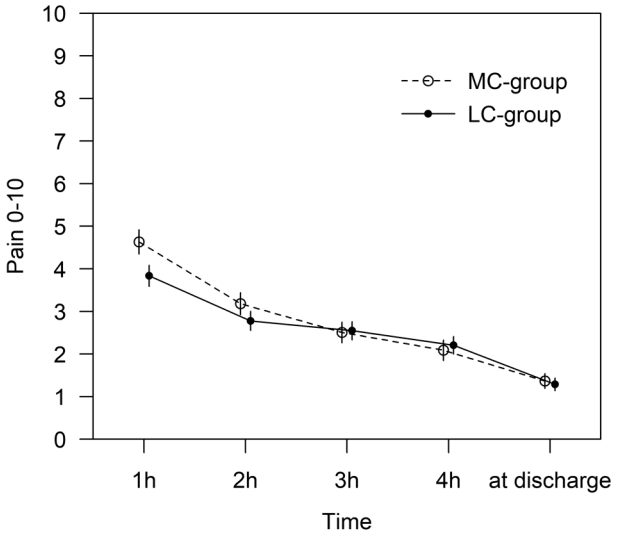

Figure 1. *Postoperative pain in minicholecystectomy (MC) and 3D-laparoscopic cholecystectomy (LC) patients, assessed with an 11-point numeric rating scale (0=no pain, 10=most pain).*

Table III. *Postoperative pain and analgesics information during the first 24 hours after surgery in the minicholecystectomy (MC) and three-dimensional laparoscopy (3D-LC) groups.*

Variable	MC n=88	3D-LC n=112	*p*-Value
Pain at 24 h			
Pain at rest	2.2 (1.9)	1.2 (1.5)	<0.001
	2 [0-8]	1 [0-7]	
Pain while coughing	4.0 (1.8)	3.3 (1.6)	0.095
	4 [0-10]	3 [0-7]	
Pain on movement	3.6 (1.8)	2.9 (1.7)	0.056
	3 [1-10]	3 [0-8]	
Number of non-opioid analgesic doses during the first 24 h	4.0 (1.8)	3.7 (1.8)	0.377
	3 [0-6]	3 [0-6]	
Efficacy of analgesics	7.4 (1.3)	7.6 (1.7)	0.878
	8 [2-9]	8 [0-10]	
Number of opioid analgesic doses	4.5 (4.4)	4.4 (4.1)	0.741
	3 [0-34]	3 [0-20]	
Total amount of opioid analgesic amount (mg)	16.8 (15.7)	16.7 (16.5)	0.953
	12 [0-98]	11 [0-88]	
Nausea (yes/no)	12/48	18/69	0.782
Vomiting (yes/no)	5/55	6/81	0.908
Normal drinking (yes/no)	59/0	86/1	0.997
Normal eating (yes/no)	58/2	85/1	0.465

Pain and analgesic efficacy were assessed with an 11-point numeric rating scale (NRS, 0=no pain/pain relief, 10=most pain/total pain relief). Data are mean (standard deviation) and median [range]. Mann-Whitney *U* and Fisher's exact tests were used.

LC patients also received less non-opioid analgesics following surgery (Table III). Nevertheless, there was no difference in the number of opioid analgesic doses, total amount of oxycodone or efficacy of analgesics during the first 24 h between the 3D-LC and MC study groups (Table III).

Recovery at four weeks. A total of 84% (94/112) of patients in the 3D-LC group and 83% (73/88) of patients in the MC group returned the health status questionnaire four weeks following operation (Table IV). The incidence of pain at rest four weeks after surgery was slightly lower in 3D-LC patients than in MC patients (6% *vs*. 8%, respectively) (Table IV). In addition, the 3D-LC patients had less pain at movement/coughing than MC patients (9%/6% *vs*. 17%/11%, respectively). The 3D-LC patients also received less analgesics following surgery (Table III), although there were no significant differences in the use of analgesics after discharge during the 4 weeks following surgery (Table IV). The success of analgesics was quite similar in the 3D-LC group compared to the MC group (p=0.89). Similarly, very high 'satisfaction with life in general' variable was documented 4 weeks postoperatively in the 3D-LC and MC study groups (91% *versus* 90%, respectively, Table IV).

Discussion

The 2D-LC with dissection by monopolar energy is the gold-standard operative technique for the management of symptomatic cholelithiasis (1-3). The MC was shown to have a comparable perioperative outcome compared to the 2D-LC and earlier follow-up studies on postoperative course indicate that these two techniques share a quite similar short-term outcome (1, 2). Harju *et al*. (1), Aspinen *et al*. (11), Kärkkäinen *et al*. (12) and Saimanen *et al*. (13) described earlier the accuracy of MC *versus* the 2D-LC options and results suggest relatively similar 5-year and 10-year outcomes after the MC and the 2D-LC techniques. The 3D-lap is a recent development in laparoscopic surgery and has been shown to enhance surgical efficacy, diminish errors, increase spatial awareness, and reduce time to complete surgical tasks in laboratory settings (4, 5). Recently, some clinical studies have tried to show whether these advantages of 3D-lap found in laboratory are transferable to the clinical environment (3, 6-8). These studies have shown conflicting results; some report benefits of 3D-lap (6-8), while others did not find advantages in using 3D-lap over conventional 2D-lap (3, 9).

The 3D-LC is uncommon in routine cholecystectomy and there are no earlier studies assessing the 3D-LC *versus* MC in cholecystectomy. The aim of our study was to show whether the 3D-LC technique could enhance patient satisfaction with lower pain scale in comparison to the MC procedure.

In the pain reports we found that the patients in the 3D-LC study group had less early postoperatively pain at

Table IV. *Postoperative recovery at 4 weeks after surgery in the minicholecystectomy (MC) and three-dimensional laparoscopy (3D-LC) groups.*

Variable	MC n=88	3D-LC n=112	*p*-Value
At 4 weeks			
Pain at rest yes/no	6/65	6/87	0.728
Pain at cough yes/no	8/63	6/88	0.656
Pain on movement yes/no	12/59	8/85	0.102
Regular use of analgesic after discharge (days)	4.7 (4.1) 3 [0-21]	4.1 (3.4) 3 [0-18]	0.353
Total use of analgesics after discharge (days)	6.5 (7.4) 5 [0-30]	5.6 (5.9) 4 [0-30]	0.526
Efficacy of analgesics	8.2 (2.1) 9 [0-10]	8.3 (1.9) 9 [0-10]	0.894
Adverse effects (yes/no)	5/57	4/68	0.555
Satisfaction with life in general (yes/no)	66/7	86/8	0.809

Analgesic efficacy was assessed with an 11-point numeric rating scale (NRS, 0=no pain relief, 10=total pain relief). Data are mean (standard deviation), median [range] or number of cases. Mann-Whitney *U* and Fisher's exact tests were used.

the one hour timepoint and the 3D-LC patients had significantly lower pain score at rest and slightly lower NRS pain scores at movement/while coughing at 24 hours following surgery. Nevertheless, no difference in the regular use of analgesic drugs or efficiency of analgesics were observed in the 3D-LC and MC study groups at four weeks after surgery.

These results of early outcome after the 3D-LC are in line with those studies using 3D-lap technique in bariatric surgery (6), hiatal hernia repair (7) or preperitoneal inguinal hernia repair (8). However, earlier 3D-lap studies have reported conflicting results; some report benefits of 3D-lap (6-8), while others did not find advantages in using 3D-lap over conventional 2D-lap (3, 9). However, the 3D-lap is rarely used in cholecystectomy and there are no trials comparing 3D-LC *versus* MC in cholecystectomy. Interestingly, our study suggests that both LC and MC techniques are comparable in safety and efficacy also when the 3D-lap is applied. The favorable effects of the 3D-lap compared to the conventional MC are represented in patient pain reports with significantly lower NRS score 24 hours postoperatively.

The strength of this study is the large cohort of patients with symptomatic gallstone disease (n=200 patients) and the use of the LME model to test the group differences for repeated measurement outcomes in the 3D-LC and MC patients (10). In LME analysis the mean NRS score values were used, whereas in Mann-Whitney *U*-test median values were used. Therefore, we decided to provide both the mean and median values to offer as much as possible information of study parameters. A limitation of the study is the lack of the blinding of the 3D-LC and MC study groups, which was impossible from the surgeons' point of view given the clinical design of the study.

In conclusion, the patient experience of pain depends on many factors. A doctor or nurse taking care of pain management at every hour postoperatively could have a positive effect on the patient satisfaction and experience of pain. However, our results suggest that both 3D-LC and MC are safe and efficient techniques for cholecystectomy. A new finding is a relatively similar short-term course in the 3D-LC and MC patients, although the 3D-LC patients reported significantly lower pain score 24 hours postoperatively.

Conflicts of Interest

The Authors report no conflicts of interest or financial ties to disclose.

Authors' Contributions

All Authors contributed to the collection and analysis of data, drafting, and revising the manuscript. All Authors read and approved the final article.

Acknowledgements

The study was funded by the Päivikki and Sakari Sohlberg Foundation, Helsinki, Finland.

References

1 Harju J, Aspinen S, Juvonen P, Kokki H and Eskelinen M: Ten-year outcome after minilaparotomy *versus* laparoscopic cholecystectomy: a prospective randomised trial. Surg Endosc *27(7)*: 2512-2516, 2013. PMID: 23344510. DOI: 10.1007/s00464-012-2770-x

2 Saimanen I, Kuosmanen V, Rahkola D, Selander T, Kärkkäinen J, Harju J, Aspinen S and Eskelinen M: RAND-36-item health survey: a comprehensive test for long-term outcome and health status following surgery. Anticancer Res *39(6)*: 2927-2933, 2019. PMID: 31177131. DOI: 10.21873/anticanres.13422

3 Koppatz H, Harju J, Sirén J, Mentula P, Scheinin T and Sallinen V: Three-dimensional *versus* two-dimensional high-definition laparoscopy in cholecystectomy: a prospective randomized controlled study. Surg Endosc *33(11)*: 3725-3731, 2019. PMID: 30710315. DOI: 10.1007/s00464-019-06666-5

4 Bloch E, Uddin N, Gannon L, Rantell K and Jain S: The effects of absence of stereopsis on performance of a simulated surgical task in two-dimensional and three-dimensional viewing conditions. Br J Ophthalmol *99(2)*: 240-245, 2015. PMID: 25185439. DOI: 10.1136/bjophthalmol-2013-304517

5 Buia A, Stockhausen F, Filmann N and Hanisch E: 3D *vs*. 2D imaging in laparoscopic surgery-an advantage? Results of standardised black box training in laparoscopic surgery. Langenbecks Arch Surg *402(1)*: 167-171, 2017. PMID: 27761712. DOI: 10.1007/s00423-016-1526-9

6 Currò G, La Malfa G, Caizzone A, Rampulla V and Navarra G: Three-dimensional (3D) *versus* two-dimensional (2D) laparoscopic bariatric surgery: a single-surgeon prospective randomized comparative study. Obes Surg *25(11)*: 2120-2124, 2015. PMID: 25893652. DOI: 10.1007/s11695-015-1674-y

7 Leon P, Rivellini R, Giudici F, Sciuto A, Pirozzi F and Corcione F: 3D vision provides shorter operative time and more accurate intraoperative surgical performance in laparoscopic hiatal hernia repair compared with 2D vision. Surg Innov *24(2)*: 155-161, 2017. PMID: 28118788. DOI: 10.1177/1553350616687434

8 Koppatz HE, Harju JI, Sirén JE, Mentula PJ, Scheinin TM and Sallinen VJ: Three-dimensional *versus* two-dimensional high-definition laparoscopy in transabdominal preperitoneal inguinal hernia repair: a prospective randomized controlled study. Surg Endosc *34(11)*: 4857-4865, 2020. PMID: 31754852. DOI: 10.1007/s00464-019-07266-z

9 Dirie NI, Wang Q and Wang S: Two-dimensional *versus* three-dimensional laparoscopic systems in urology: a systematic review and meta-analysis. J Endourol *32(9)*: 781-790, 2018. PMID: 29969912. DOI: 10.1089/end.2018.0411

10 McLean R, Sanders W and Stroup W: A unified approach to mixed linear models. The American Statistician *45(1)*: 54, 2018. DOI: 10.2307/2685241

11 Aspinen S, Harju J, Juvonen P, Karjalainen K, Kokki H, Paajanen H and Eskelinen M: A prospective, randomized study comparing minilaparotomy and laparoscopic cholecystectomy as a day-surgery procedure: 5-year outcome. Surg Endosc *28(3)*: 827-832, 2014. PMID: 24196543. DOI: 10.1007/s00464-013-3214-y

12 Kärkkäinen J, Saimanen I, Selander T, Aspinen S, Harju J, Juvonen P and Eskelinen M: Gallstone patients with enhanced oxidative stress biomarker superoxide dismutase (SOD1) plasma levels have significantly lower number of postoperative analgesic oxycodone doses: a prospective study with special reference to cancer patients. Anticancer Res *38(6)*: 3573-3578, 2018. PMID: 29848712. DOI: 10.21873/anticanres.12630

13 Saimanen I, Kuosmanen V, Kärkkäinen J, Selander T, Aspinen S, Holopainen A, Rantanen T and Eskelinen M: Cholecystectomy patients with high plasma level of catalase have significantly lower analgesia requirement: a prospective study of two different cholecystectomy techniques with special reference to patients with cancer. Anticancer Res *38(9)*: 5417-5422, 2018. PMID: 30194197. DOI: 10.21873/anticanres.12872

Received September 18, 2022
Revised October 1, 2022
Accepted October 6, 2022