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Fewer Ports Cut Opioid Use and Length of Stay in Elective Laparoscopic Cholecystectomy

Terry Chiung Ta Lu, BMBS, Philip Gan, MD, Vincent Versace, PhD

ABSTRACT

Background: Postoperative pain is one of the most common reasons for prolonged hospital stay with opioid analgesia the mainstay of treatment.

Objectives: The purpose of this study was to determine whether the degree of abdominal trauma, reflected by the number and sizes of ports used in elective laparoscopic cholecystectomy, correlated against opioid analgesia requirements and length of stay.

Methods: A retrospective clinical audit was undertaken of 144 patients who underwent elective laparoscopic cholecystectomies with 3-port (12/5/5) and 4-port approaches (12/5/5/5 and 12/10/5/5). In the reduced port cases, liver retraction was achieved using a suction retractor, removing the requirement for a fourth port. The number of ports and total cross-sectional area of all ports were compared against the procedure time, length of stay, and opioid analgesia required.

Results: The smaller total cross-sectional area associated with the 3-port approach (12/5/5, 277.25 mm^2) resulted in significantly lower total oral morphine equivalent daily dose required compared to 12/10/5/5 (453.96 mm^2) and 12/5/5/5 (327.52 mm^2) approaches, being 30.7 mg and 21.0 mg less, respectively ($p < 0.001$). The 3-port approach had a mean length of stay 0.8 days which was significantly shorter compared to both 4-port approaches ($p = 0.001$, length of stay of 1.1 and 1.2 days for 12/5/5/5 and 12/10/5/5, respectively). Laparoscopic cholecystectomy patients in the study hospitals routinely stayed overnight.

Conclusions: The absolute number of ports used in elective laparoscopic cholecystectomies appears to play an important role in postoperative recovery. In particular, 3-port configurations may result in less postoperative pain without the burden of an increase in length of stay, morbidity, or mortality rates.

Key Words: Enhanced Recovery After Surgery (ERAS), Laparoscopic cholecystectomy, Reduced port surgery, Liver retractor.

INTRODUCTION

Hospital expenditure is the largest contributor to public spending, and length of stay (LOS) is a key driver of hospital expense and efficiency. Greater postoperative pain, in turn, is one of the most important and common reasons for increased length of stay.[1,2] Opioid analgesia is the mainstay of treatment for acute postoperative pain,[3] but can be associated with side effects such as nausea and risk of narcotic dependence. Incisional pain is the most common cause of early postoperative pain after elective laparoscopic cholecystectomy (ELC).[4,5] It is therefore reasonable to deduce that the number and size of laparoscopic ports placed will affect the levels of pain and subsequently the requirement for opioid analgesia.

Postoperative pain is also a major determinant of patient reported outcome measures.[6] Incisional abdominal wall trauma is a greater contributor to pain than visceral trauma as evidenced by the enhanced recovery following laparoscopic versus open surgery.[7,8] The cross-sectional area (CSA) of a laparoscopic port, being cylindrical, more accurately measures tissue displacement, and therefore

Department of General Surgery, South West Healthcare, Victoria, Australia (Drs Lu and Gan)

Deakin Rural Health, School of Medicine, Deakin University, Geelong, Victoria, Australia (Dr Versace)

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Address correspondence to: Dr. Terry Chiung Ta Lu, Department of General Surgery, South West Healthcare, 25 Ryot Street, Warrnambool, Victoria, Australia, Telephone: +61 423 644 390, E-mail: tclu16@icloud.com.

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abdominal wall trauma, than the diameter of the port. The CSA varies as the square of the radius ($A = \pi r^2$), hence each increment has an exponential effect.[9]

In this study, it was hypothesized that the degree of abdominal trauma, as measured by the number of ports and port sizes, would have an additive effect. These factors were correlated against both the dose of opioid analgesia required and length of stay (LOS).

METHOD

Data Collection

This retrospective clinical study was performed at a regional health service in Victoria, Australia, after obtaining ethics approval. Data collection and analysis was undertaken in accordance with the principles of research ethics and standards outlined by the National Health and Medical Research Council.

A retrospective audit was undertaken of all patients who underwent elective laparoscopic cholecystectomies performed by any of the general surgeons belonging to this regional health service's surgical department from January 1, 2015 to August 15, 2017. Basic demographics, American Society of Anesthesiologists (ASA) score, surgical technique, duration of procedure, and analgesia requirements were collected from paper and electronic medical records. With regards to the surgical technique, data points recorded included the type, number, and size of ports and whether an intra-operative cholangiogram was performed. The Clavien Dindo classification of operative complications and LOS were recorded.[10] All of the single-incision laparoscopic surgery (SILS) and 3-port ELCs were performed by one general surgeon, with the 4-port approaches being performed by the other general surgeons in the Department of Surgery. In the reduced port cases, liver retraction was achieved using the suction retractor (LiVac Retractor™ Melbourne, Australia). Furthermore, each port makes its own contribution to pain – in this study, the absolute number of ports (incisions) used was analyzed separately to the additive cross-sectional area of all ports used. The additive area was used as a score to reflect abdominal wall trauma. Due to low numbers (n = 5), the SILS cases were excluded from analysis.

Selection Criteria

Exclusion criteria were nonelective patients, children (age under 18 years), patients with an ASA greater than 2; known choledocholithiasis, pancreatitis, or cholangitis; additional significant intra-abdominal procedures, those who required anticoagulation, and operations requiring open conversion. A total of 154 patients remained after applying these exclusion criteria during the data collection period.

Outcomes Variables

Total cross-sectional area (T-CSA) was defined as the sum of the cross-sectional area of each port as calculated using its outer diameter. The total opioid analgesia requirement was defined by the sum of the opioid analgesia required in the recovery unit, as well as on the ward. This included the regular and breakthrough doses of opioid analgesia. The route of administration and dose of opioid analgesia was tabulated, and the oral morphine equivalent daily dose (oMEDD) calculated using the Australian and New Zealand College of Anaesthetists Faculty of Pain Medicine opioid equivalence table.[11]

Statistical Methods

Continuous demographic variables were compared using t-tests, and categorical variables using Pearson's χ^2 test. Comparisons between the port configurations used planned contrasts based upon the hypotheses that a smaller surface area would lead to (1) reduced procedure time, (2) reduced LOS, (3) reduced recovery oMEDD, and (4) reduced total oMEDD (Contrast 1 Group A vs. Group B and Group C; Contrast 2 Group B vs. Group C). Levene's Test for Equality of Variances was applied, and where violated, the Welch-Satterthwaite method was used. All analyses were undertaken in SPSS version 25.[12]

RESULTS

A total of 154 patients met the inclusion criteria. In this study, the 12/5/5 (Group A), 12/5/5/5 (Group B), and 12/10/5/5 (Group C) port configurations accounted for 93.5% of the operations (n = 144). All analyses presented are restricted to this subset. There was not a significant difference in the age of patients across the three surgery types (**Table 1**), and there was no association between gender and the group of surgery (χ^2 (14, n = 144)=10.90, P = .872).

The smaller total cross-sectional area associated with the 3-port approach (Group A, 277.25 mm^2) resulted in significantly lower total oMEDD required compared to Group C (453.96 mm^2) and Group B (327.52 mm^2) approaches,

Table 1.
Planned Contrasts Between the Different Types of Surgery. Port Configuration 12/5/5 (Group A); Port Configuration 12/5/5/5 (Group B); Port Configuration 12/10/5/5 (Group C)

		n	Mean (SD)	t (Degrees of Freedom)	p-Value
Contrast 1					
Age (Years)	Group A	46	47.7 (17.3)	0.622 (142)	0.535
	Group B and Group C	98	45.8 (16.3)		
Length of Stay (days)	Group A	46	0.8 (0.6)	−3.495 (74.742)	0.001
	Group B and Group C	98	1.2 (0.5)		
Procedure time (minutes)	Group A	46	58.3 (16.5)	−8.245 (142)	<0.001
	Group B and Group C	98	89.4 (22.9)		
Recovery oMEDD (mg)	Group A	46	10.7 (15.2)	−1.159 (142)	0.248
	Group B and Group C	98	14.0 (16.2)		
Total oMEDD (mg)	Group A	46	31.6 (30.3)	−3.901 (142)	<0.001
	Group B and Group C	98	56.8 (38.5)		
Contrast 2					
Age (years)	Group B	56	46.6 (16.9)	0.544 (96)	0.588
	Group C	42	44.8 (15.6)		
Length of Stay (days)	Group B	56	1.1 (0.4)	−0.931 (96)	0.354
	Group C	42	1.2 (0.6)		
Procedure time (minutes)	Group B	56	82.4 (19.8)	−3.715 (96)	<0.001
	Group C	42	98.7 (23.7)		
Recovery oMEDD (mg)	Group B	56	13.0 (15.0)	−0.655 (96)	0.514
	Group C	42	15.2 (17.8)		
Total oMEDD (mg)	Group B	56	52.6 (35.0)	−1.227 (96)	0.223
	Group C	42	62.3 (42.6)		

SD, standard deviation; oMEDD, oral morphine equivalent daily dose.

30.7 mg and 21.0 mg less, respectively ($P < .001$). The 3-port approach had a mean LOS of 0.8 days which was significantly shorter compared to both 4-port approaches ($P = .001$, LOS of 1.1 and 1.2 days for Group B and Group C respectively) (**Table 1**). The 3-port approach had 0% in-hospital morbidity whilst the two 4-port approaches had similar morbidity rates of 7.1% (Group B) and 9.5% (Group C) with Clavien Dindo classifications ranging from 1 to 2.[10] There were no mortalities in all groups. The performance of an intra-operative cholangiogram did not statistically influence the total oMEDD required.

DISCUSSION

The hypothesis of this study was that increasing the T-CSA of all laparoscopic ports would correlate positively with oMEDD; however, this was only demonstrated between the 3-port and 4-port approaches (**Figure 1**). Indeed, the difference in T-CSA was greater between the two 4-port variants than between the 3 and 4-port approaches, due to the exponential effect of the radius on the cross-sectional area. There was a trend to higher total oMEDD requirement for the 12/10/5/5 versus 12/5/5/5 port approaches; however, this did not reach statistical significance ($P = .545$). As such, it appears that the number of laparoscopic ports has a greater influence on oMEDD requirements and pain than the T-CSA, at least for laparoscopic ports in the 5–10 mm range. The risk of port site hernia and cosmetic outcome was not measured in this study. A typical cosmetic outcome from the 3-port approach, however, is shown in **Figure 2**

With regards to patient selection, the intention was to focus on elective cholecystectomies in otherwise well (ASA 1 – 2) patients, as it is established that emergency

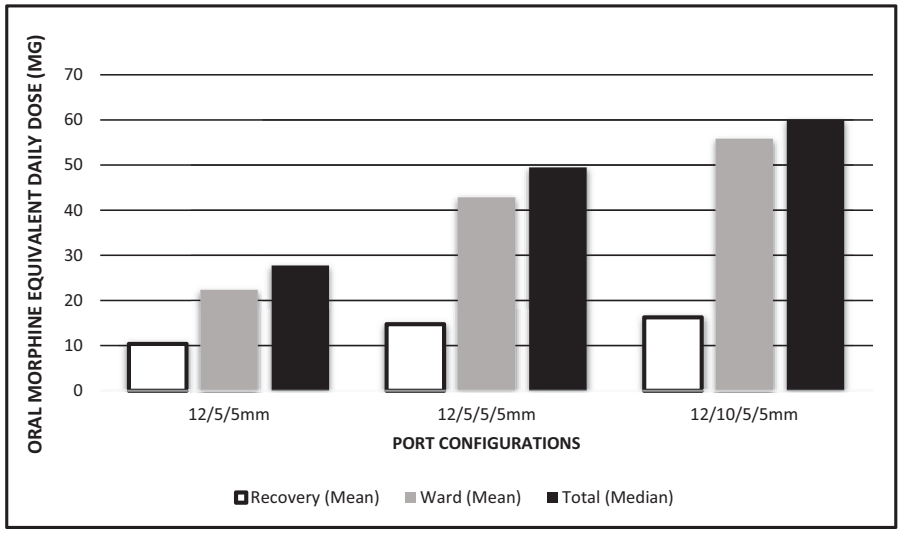

Figure 1. Opioid analgesia required after elective laparoscopic cholecystectomy.

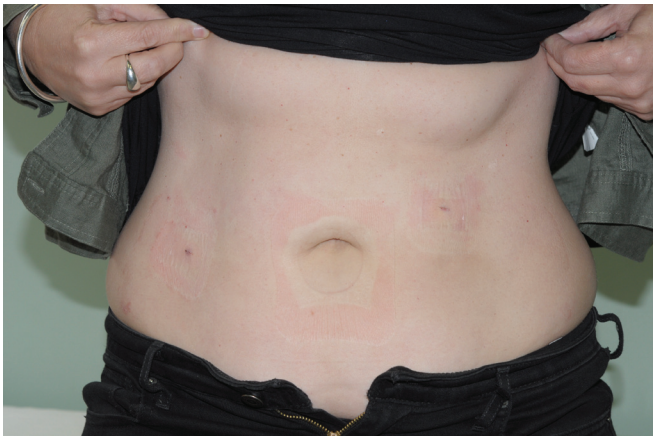

Figure 2. Day 6 post 3-port cholecystectomy.

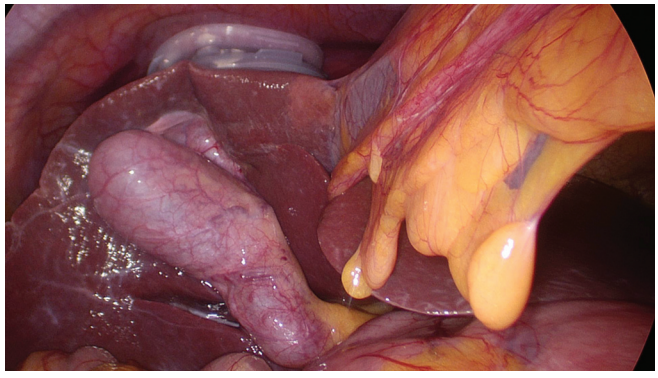

Figure 3. Liver retraction using the LiVac™ retractor system.

operations and comorbid patients are independent variables for increased length of stay. 30≤ BMI ≤ 40 is classified as ASA 2, whereas BMI ≥ 40 falls into ASA 3. The ASA rating was made by the anesthetists, hence it can be reasonably inferred that the patients in this study were under BMI 40 and without severe comorbidities.

The minimum instrumentation has required access for the laparoscope, dissecting grasper, and dissecting instrument (Maryland, hook diathermy, etc.), hence even single port devices have required at least three channels. The fourth port (or channel) is typically relegated to the assistant, for retraction of the right lobe of liver or gallbladder to improve the exposure of the critical view of safety.[13] In this study, the fourth port was generally replaced by a suction retractor in the reduced port cases (**Figures 3** and **4**). This retractor utilizes regulated wall suction to achieve a vacuum in the center of a soft silicone ring which is placed between the upper surface of liver and the diaphragm, thereby lifting the liver to expose the gallbladder. The suction tubing which runs from the suction ring to the wall suction hose exits alongside the Hasson/12 mm port, thereby sharing that incision. This configuration was associated with both reduced oMEDD requirements and LOS, and without increased morbidity.

In a meta-analysis, Markar et al. found that there was no significant difference in postoperative pain scores or LOS when comparing SILS to conventional multiport cholecystectomies.[14] In our study, the small number of SILS cases

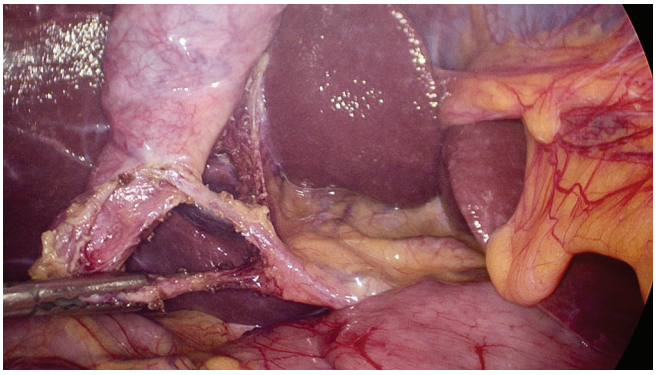

Figure 4. Critical view of safety in 3-port surgery.

(n = 5) precluded them from statistical analysis. The total opioids required ranged from 22 to 150 mg throughout the inpatient stay with an average oMEDD requirement of 79.6 mg. Although it is only the one trocar, the total surface area for SILS is much greater at 771.91 mm^2. Studies on double-incision laparoscopic cholecystectomies found average LOS from 1.21–10.5 days with similar postoperative pain compared to SILS as well as conventional laparoscopic cholecystectomies.[15,16]

The average LOS for cholecystectomy in hospitals from the same peer group in 2011 to 2012 was 2.0 days.[2] In our study, the mean LOS for 3-port and 4-port ELC was 0.8 and 1.2 days, respectively. There were 17 patients who had LOS greater than 1 day. The most common reason for this was increased drain output (n = 4) followed by pain, constipation, and hypotension. There was a trend to shorter duration of surgery with the 3-port approach, although this most likely reflects the techniques of that (individual) surgeon.

All surgeons had at least 10 years' operative experience as a consultant surgeon and performed laparoscopic cholecystectomies regularly as part of their operative case-mix. As all the 3-port laparoscopic cholecystectomies were performed by one surgeon, the possibility that there were other factors implicated in the reduced oMEDD and LOS data cannot be ruled out. The surgeon who performed the 3-port cholecystectomies only performed 4-port cholecystectomies where the patients' liver and/or diaphragm anatomy precluded use of the suction retractor, which relies upon reasonably planar surfaces in order to achieve a seal. Most patients do have suitable anatomy for this device, and the surgeon generally maintains a 3-port approach even in emergency cholecystectomies. As such, the selection for 4-port cholecystectomy with this surgeon had more to do with patient anatomy being unsuited to the suction retractor device than the difficulty of the case or pathology encountered. Nonetheless, even when just this surgeon's patients were reviewed, his 3-port cholecystectomies (n = 45) had an average oMEDD of 30.78 mg compared with 56.21 mg for his 4-port cholecystectomies (n = 9). Due to the small sample sizes comparing these two cohorts, the difference did not reach statistical significance (P = .2227, unpaired t test). A further prospective study randomizing 3-port vs. 4-port approaches by the same surgeon would remove this variable.

Whilst a gold standard study assessing the effect of port numbers on postoperative pain, analgesia requirements would be a prospective randomized trial whereby port numbers and sizes were the only variables, it would also be difficult to blind due to the necessity of accurate operation report documentation. Furthermore, observer bias in such a prospective study may not be completely eliminated, knowing which surgical approach was used.

Although there was no documented 'pain protocol' in this retrospective study, in practice, the selection of postoperative analgesics is fairly limited to acetaminophen (paracetamol), which is charted regularly once per day, with additional Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) and opioids administered on an as needed basis. Parenteral NSAIDS are routinely administered by anesthetists at induction, thereby limiting what further dose of NSAIDs are able to be administered on the day of surgery. The main choice of analgesia following general anesthesia on the day of surgery is therefore some form of opioid. Each opioid has been standardized to an oral morphine equivalent. As there was no matching of anesthetist to surgeon, the main variables are the surgeons and the techniques employed by each. No data was collected on the use of drains or otherwise, nor of the surgeons' individual practices with regard to local anesthetic infiltration, although it has been standard practice among the surgeons to use local anesthetic into the laparoscopic wounds. This may partially explain the lack of statistical significance between the total oMEDD required in recovery among the three groups when the local anesthetic was still effective.

The retrospective nature of this study is clearly acknowledged by the authors, but also reflects the "real world" observations made over a 32-month period whereby the judgements to administer opioid analgesia were made by a myriad of nurses caring for these patients following their operations in a public hospital setting. While one might argue that the choice of which opioid to use and when after surgery could be subjective by an individual nurse, when we are considering a multitude of nurses over such a protracted period, there is no

(consistent) subjectivity. It is also reasonable to infer that the oMEDD requirements reflected the pain levels of the patients, in the absence of a contemporaneously recorded Visual Analogue Scale pain score. The authors did not collect data on the patient's opioid naivety status although this would be of value in future studies.

The use of opioid analgesia for peri-operative pain management has also led to an "opioid crisis" with de novo prescription narcotic dependence. Patients undergoing laparoscopic cholecystectomy were included amongst those operations leading to a "significantly increased risk for chronic opioid use after surgery".[17]

An Australian government report[18] on laparoscopic cholecystectomy in 2012 described an average cost of AUD $4600 for a day case procedure versus AUD $6000 for a one-night stay. This $1400 difference could account for the cost of several suction retractor devices, assuming that the reduced port technique was overall associated with fewer overnight stays. As such, the overall cost of admission should be considered, rather than cost of device in isolation.

In Australia, the impact of reduced LOS has more to do with whether the patient stays overnight. The LOS for a day procedure is 0.8, whereas 1 or more refers to post-operative days in hospital. Staying overnight means that a ward bed must be staffed by night nurses and the patient will occupy that bed until discharge the following day. This adds to the surgical and nursing rounds, administrative processes around bed management, planning for further elective surgery and emergency admissions, and coordination of discharge planning and new admissions into that bed. Bed shortages are a perennial and pervasive issue, hampering the efficiency of healthcare delivery, hence there are great advantages with increasing the proportion of day procedure cholecystectomies. It is worth noting that laparoscopic cholecystectomies in Australia have traditionally been performed as in-patient (overnight) procedures, hence out-patient cholecystectomy is not common practice. There were 55,236 cholecystectomies performed in Australia from July 2015 to June 2016, with 93.5% performed laparoscopically. It was the most common general surgical operation followed by appendectomy and inguinal hernia repair.[8] It follows that a reduction in average LOS by one day (e.g., overnight to same-day stay, or two days to one, etc.) could result in savings in the order of AUD $55,000,000 nationally per year. This would need to be adjusted in line with the selection criteria applied to this cohort, given that the total number nation-wide would include a broader demographic and emergency cases.

CONCLUSION

In this retrospective analysis, the 3-port approach is associated with significantly lower opioid analgesic requirements in elective laparoscopic cholecystectomies compared to 4-port approaches. The 3-port approach was facilitated using a liver suction retractor with its cost being offset by the fourth port that it replaced. There was no statistically significant difference between increasing total port site cross-sectional areas and increasing opioid requirements between the two 4-port groups, although there was a trend to higher oMEDD and LOS with the 12/10/5/5 group (Group C). In conclusion, the absolute number of ports used in elective laparoscopic cholecystectomies appears to play an important role in postoperative recovery. In particular, 3-port configurations may result in less post-operative pain without the burden of an increase in length of stay, morbidity, or mortality rates.

References:

1. Gurusamy KS, Junnarkar S, Farouk M, Davidson BR. Day-case versus overnight stay in laparoscopic cholecystectomy. *Cochrane Database Syst Rev.* 2008(1):CD006798.

2. Victorian Auditor-General's Office. Hospital Performance: Length of Stay. 2016;2015-16:22. Published. 2016. Available at: https://www.audit.vic.gov.au/sites/default/files/20160210-Length-of-Stay.pdf.

3. Ramsay MA. Acute postoperative pain management. *Proc (Bayl Univ Med Cent)).* 2000;13(3):244–247.

4. Bisgaard T, Kehlet H, Rosenberg J. Pain and convalescence after laparoscopic cholecystectomy. *Eur J Surg.* 2001;167(2):84–96.

5. Bisgaard T, Klarskov B, Rosenberg J, Kehlet H. Characteristics and prediction of early pain after laparoscopic cholecystectomy. *Pain.* 2001;90(3):261–269.

6. McLean KA, Sheng Z, O'Neill S, et al. The Influence of clinical and patient-reported outcomes on post-surgery satisfaction in cholecystectomy patients. *World J Surg.* 2017;41(7):1752–1761.

7. Reynolds W Jr., The first laparoscopic cholecystectomy. *JSLS.* 2001;5(1):89–94.

8. Burgess K, Christian L, McIntyre J, Mole T. *Admitted patient care 2015–16: Australian Hospital Statistics.* Canberra: Australian Institute of Health and Welfare.2017. Available at:

https://www.aihw.gov.au/getmedia/3e1d7d7e-26d9-44fb-8549-aa30ccff100a/20742.pdf.aspx?inline=true.

9. de Carvalho GL, Cavazzola LT. Can mathematic formulas help us with our patients? *Surg Endosc.* 2011;25(1):336–337.

10. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg.* 2009;250(2):187–196.

11. Australian and New Zealand College of Anaesthetists. Opioid dose equivalence - calculation of oral morphine equivalent daily dose (oMEDD). 2015. Available at: http://fpm.anzca.edu.au/documents/opioid-dose-equivalence.pdf.

12. *IBM SPSS Statistics for Windows [computer program].* Version 25.0. Armonk, NY: IBM Corp 2017.

13. Singh R, Brunt LM. Critical view of safety—its feasibility and efficacy in preventing bile duct injuries. *Ann Laparosc Endosc Surg.* 2018;3(1):2.

14. Markar SR, Karthikesalingam A, Thrumurthy S, Muirhead L, Kinross J, Paraskeva P. Single-incision laparoscopic surgery (SILS) vs. conventional multiport cholecystectomy: systematic review and meta-analysis. *Surg Endosc.* 2012;26(5):1205–1213.

15. D'Antonio D, Franzato B, Fusco G, Ruperto M, Dal Pozzo A. Double incision laparoscopic cholecystectomy (DILC) with routinary intra-operative cholangiography (IOC). *Updates Surg.* 2013;65(2):109–114.

16. Sabuncuoglu MZ, Benzin MF, Cakir T, Sozen I, Sabuncuoglu A. Triple, double- and single-incision laparoscopic cholecystectomy: a prospective study. *Int J Clin Exp Med.* 2014;7(10):3385–3391.

17. Hah JM, Bateman BT, Ratliff J, Curtin C, Sun E. Chronic opioid use after surgery: implications for perioperative management in the face of the opioid epidemic. *Anesth Analg.* 2017;125-(5):1733–1740.

18. National Health Performance Authority. Hospital performance: costs of acute admitted patients in public hospitals in 2011-12.2015. Available at: https://www.aihw.gov.au/getmedia/1fc59c7b-1fdb-4bbc-862c-99beaa2c73c0/hp_costsofacuteadmittedpatients_2011_12_rpt.pdf.aspx?inline=true.