REVIEW ARTICLE

Optimising Surgical Technique in Laparoscopic Cholecystectomy: a Review of Intraoperative Interventions

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Abstract

Background Laparoscopic cholecystectomy (LC) is one of the most commonly performed procedures worldwide but there is considerable variance amongst surgeons regarding intraoperative technique. This review aims to provide a comprehensive summary, with evidence-based recommendations, of intraoperative interventions in LC.

Methods A literature search was performed using PubMed, EMBASE, Google Scholar and Cochrane Review databases. Articles were screened for eligibility with inclusion criteria based on study design, surgical approach, surgical timing, pathology and intervention type. The most contemporary, comprehensive or relevant articles were used as the primary evidence for the final analysis and discussion.

Results A total of 25 systematic reviews and/or meta-analyses and 19 individual trials were identified from the literature and grouped into ten clinical intervention topics. Three intraoperative interventions offer clinical benefit and are recommended: wound/intraperitoneal local anaesthetic, low-pressure pneumoperitoneum and manoeuvres to reduce residual pneumoperitoneum. No benefit was demonstrated for routine subhepatic drain placement and gallbladder aspiration. Techniques which appear to demonstrate improvements but do not translate into clinical efficacy are the use of warmed/humidified carbon dioxide, installation of intraperitoneal saline and the use of advanced imaging techniques. Techniques demonstrating equipoise, and for which no recommendations can be made, are type of energy source and cystic duct occlusion methods.

Discussion This review highlights and suggests specific intraoperative techniques during uncomplicated LC that should be employed, avoided or considered by the individual surgeon. Optimising surgical technique in this way can lead to improved patient outcomes.

Introduction

Since the first minimally invasive cholecystectomies in the mid-1980s, laparoscopic cholecystectomy (LC) has increased such that it is now one of the most commonly performed procedures worldwide. Although cholecystectomy has often been the 'pilot' procedure for innovations such as single port or natural orifice transluminal endoscopic surgery, the majority are still performed by a standard four-port laparoscopic method. Attempts are continually made to refine the standard LC technique in a bid to reduce morbidity, improve outcomes and enhance recovery but there is still considerable variance in intraoperative practices. Existing literature relates principally to strategies to reduce post-operative pain after LC[1,2] or techniques to reduce biliary injury.[3] The aim of this review is to provide a comprehensive literature review and provide recommendations for any intraoperative interventions in uncomplicated LC, which are supported by high-level evidence and that may improve outcomes if adopted.

Methods

A search of the literature was performed using PubMed, EMBASE, Google Scholar and Cochrane database of systematic reviews to 31st of March 2018. There was no restriction on the year of publication; only English language studies were

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included. Titles and abstracts were screened to identify relevant articles for inclusion. A subsequent citation search was performed to identify any unidentified or contemporary papers. The search terms were 'cholecystectomy', 'systematic review' (SR), 'meta-analysis' (MA) and 'randomised controlled trial (RCT)' (or variants) as keywords, MeSH headings and free text.

Records arising from the database search were screened for eligibility and inclusion by the following criteria: *Study design* (SR/ MA/ RCT or high-quality cohort studies); *Surgical approach* (standard multiport LC technique); *Surgical timing and pathology* (uncomplicated, elective cholecystectomy for gallstone disease) and *Intervention* (any surgeon-selected intraoperative interventions or techniques). Studies were excluded if they evaluated acute cholecystitis, gallbladder malignancy, non-elective cholecystectomy, anaesthetic technique or interventions usually requiring preoperative decision-making such as antibiotic administration or use of intraoperative cholangiography. The most contemporary, comprehensive or relevant MAs and SRs were used as the principal evidence source for recommendations, with older or lower evidence level papers discussed secondarily.

The GRADE (Grading of Recommendations, Assessment, Development and Evaluations) framework was used to assess the quality of evidence (high/ moderate/ low/ very low) and strength of recommendations (weak/ strong) by two reviewers (S.W., R.E.), independently.[4, 5] Two hundred three articles were initially identified and a total of 25 SRs/ MAs and 20 individual trials deemed suitable for inclusion. Ten clinical topics were created based on these articles.

Results

Local Anaesthetic

Local anaesthetic (LA) is used widely in LC, in addition to systemic analgesia, to reduce postoperative pain, allowing early mobilisation and discharge. LA can be administered via port site wound infiltration, intraperitoneal instillation and regional field blocks.

A SR of LA wound infiltration during LC, based on 19 trials involving 1263 patients, concluded that pain scores were lower in the LA group at all time points up to 24 h postoperatively when compared with no LA infiltration or inactive infiltration (on a 0–10 visual analogue scale (VAS), mean difference of − 1.33 at 4–8 h and − 0.36 at 9–24 h).[6] However, the evidence was very low quality and the clinical importance was small, given the magnitude of pain improvement. Adverse events were rare, with data for quality of life, time return to normal activity or work, either imprecise or absent. There was no evidence to support the use of any

specific LA agent or administering it at a particular stage of the procedure.

Two SRs have assessed the effectiveness of intraperitoneal instillation of LA (IPLA) during LC, although there is significant overlap of the evidence.[7, 8] The 2014 review, involving 2849 patients, showed significant improvements in VAS scores up to 24 h postoperatively, for participants receiving IPLA versus controls (MD − 0.99 at 4–8 h, − 0.53 at 9–24 h); this was based on very low-quality evidence and the magnitude of clinical importance small.[8] The earlier review concluded there were significantly less opioid use/rescue analgesia and reduced cortisol and glucose responses with IPLA.[7] Both reviews note that the included trials are heterogenous with significant differences in the location and timing of LA instillation. A review in 2015 showed IPLA has a beneficial effect in reducing abdominal, visceral and shoulder-tip pain at rest.[9] A further SR confirmed there is no significant evidence as to the best method of using IPLA in terms of agent, timing of delivery, specific delivery method or location of LA application.[10]

Subsequent RCTs have attempted to provide evidence for optimising the technique of IPLA administration or combining it with other analgesic methods. One RCT (90 participants) suggests ropivacaine (0.375%) may be more effective and longer-acting than bupivacaine (0.25%) when using IPLA.[11] Another RCT (100 patients) demonstrated superior postoperative pain relief with pre-emptive instillation of intraperitoneal ropivacaine compared with instillation at the completion of surgery.[12] Studies demonstrate improved pain control with combined subcutaneous LA and IPLA, compared with either in isolation,[13, 14] or by combining IPLA with clonidine.[15]

Summary/Recommendations

- The use of LA wound infiltration or IPLA reduces postoperative pain after uncomplicated LC. (*moderate-quality evidence, strong recommendation*)
- Efficacy of IPLA might be improved by optimising technique such as specific LA agent, pre-emptive delivery or combining IPLA with wound LA or clonidine. (*moderate-quality evidence, weak recommendation*)

Routine Drain Placement

In the era of open cholecystectomy, routine placement of a subhepatic drain was common, aiming to detect postoperative bile leak or bleeding. With the advent of LC, this practice was continued by some surgeons, with others dispensing with the technique.

The largest SR and MA comparing outcomes of 'routine drain' versus 'no drain' was published in 2016 and included

data from 2396 participants in 16 trials.[16] The principal findings were that drain placement prolonged operative time and resulted in worse pain scores at 24 h postoperatively; there was no difference between the two groups for mortality, wound infection, intra-abdominal fluid volume or postoperative nausea and vomiting (PONV). These same findings were broadly demonstrated by previous SRs in 2013, 2014 and 2015,[17–19] albeit with considerable overlap of trial data, and by one subsequent RCT.[20]

Summary/Recommendations

- Routine placement of subhepatic drains after uncomplicated cholecystectomy offers no clinical advantage, may worsen outcomes, and therefore should not be used. *(high-quality evidence, strong recommendation)*

Pneumoperitoneum Pressure

In standard LC, sufficient insufflation pressure (conventionally 12–15 mmHg) is required for adequate exposure of the surgical field; excessive intra-abdominal pressures can result in deleterious physiological changes and contribute to postoperative pain. It has been postulated that lower pressures (< 12 mmHg) may result in improvement of clinically relevant outcomes. Abdominal wall lift (AWL), as an alternative technique, equates to a reduced/ atmospheric intraperitoneal pressure.

The most recent SR to look at the use of low-pressure pneumoperitoneum included studies from several laparoscopic procedures but the majority of data pertained to LC (29 of 33 RCTs).[21] The studies were heterogenous in their definition of 'low pressure' which ranged from 6 to 10 mmHg. A meta-analysis demonstrated low-pressure pneumoperitoneum reduced overall pain scores (VAS 0–10 scale) after 1 h (MD − 0.41), 1 day (MD − 0.66), 2 days (MD − 1.1) and 3 days (MD − 0.99); a mean difference of > 1.0 point was deemed clinically relevant. Similar improvements in postoperative pain were also observed in a previous SR involving 1263 patients.[22] For cardiac and pulmonary function outcomes, there were no consistent objective or clinical differences between low and standard pressure groups, and only minor differences in hepatic or renal function noted, neither of which correlated to a worsening of clinical outcomes.[21] Two SRs showed slightly longer operating time (MD 2 min, $p < 0.001$; and MD 1.5 min, 95%CI 0.07–2.94)[22, 23] and one a shorter length of hospital stay (MD − 0.27 days, $p = 0.01$) for the low-pressure group.[23] There was significant duplication of data but both conclude that low-pressure pneumoperitoneum demonstrates no difference in conversion rates or observable surgical complications.[22, 23] It should be noted, however, it is not possible for either SR to exclude a difference in biliary injuries

because the relatively low number of patients (< 1300) included in the reviews is underpowered for evaluating the effect of low-pressure pneumoperitoneum on the rate of bile duct injury (typically < 0.5%). Two subsequent RCTs, involving 50 and 80 patients, were consistent with SR findings[21] that shoulder pain is reduced in low-pressure LC with no other clinical or physiological differences.[24, 25]

The most recent SR evaluating AWL included any laparoscopic procedure but 14 of 19 studies concerned LC.[26] AWL demonstrated modest effects in lowering PaCO2 level (MD − 3 mmHg, $p < 0.001$), reducing the incidence of PONV (OR 0.24, $p = 0.001$) and shortening time to resume normal activity (MD − 0.23 days, $p = 0.001$).[26] A prior SR noted prolonged operative time for AWL (MD 8.6 min, $p = 0.002$), without an increase in serious adverse events.[27]

Summary/Recommendations

- Low-pressure pneumoperitoneum (6–10 mmHg) appears safe, reduces clinically relevant postoperative pain scores up to 3 days after surgery and may be considered for LC. *(high-quality evidence, weak recommendation)*
- There are no advantages of AWL over standard pneumoperitoneum in LC, but its use may prolong operating time and therefore cannot be routinely recommended *(high-quality evidence, weak recommendation)*

Warmed or Humidified Insufflation Gas

Intraoperative hypothermia is relatively common and can cause significant adverse events including myocardial ischaemia, coagulopathy and higher rates of sepsis and mortality.[28] In laparoscopic surgery, it is suggested that the use of warmed +/− humidified insufflation gas may also reduce postoperative pain scores.

The most relevant MA evaluated warmed versus standard temperature CO_2 insufflation in LC, pooling data from six RCTs (369 patients).[29] It concluded that there was no significant difference in pain scores or analgesia use between the two groups up to 48 h postoperatively. Three more recent SRs, with significantly duplicated data, assessed the effects of warmed +/− humidified pneumoperitoneum gas for a variety of laparoscopic procedures, with cholecystectomy patients accounting for 23–50% of the data.[28, 30, 31] Despite a small increase in core temperature (MD 0.3 °C; 95%CI 0.1–0.6 °C and MD 0.29 °C; 95%CI 0.05–0.52 °C) in the heated/ humidified insufflation groups,[28, 30] the only statistically significant improvement was in immediate (0–8 h) postoperative pain scores (MD − 0.23 on 10 point VAS, $p = 0.028$) in one SR, but this is unlikely to be clinically important.[31] The remaining outcomes, including lens fogging, operating time,

shoulder pain, analgesia requirements and hospital stay, were similar when compared with the standard insufflation.[30, 31]

Summary/Recommendations

- The use of warmed, humidified CO_2 for insufflation during LC does not lead to any significant beneficial clinical outcomes and cannot be recommended for routine usage. *(high-quality evidence, weak recommendation)*

Manoeuvres to Reduce Residual Pneumoperitoneum

Symptoms of abdominal and shoulder pain after LC may be explained by residual insufflation gas and methods have been suggested to minimize this volume postoperatively. The only SR addressing this topic evaluated any 'pulmonary recruitment manoeuvre' but only one of the six studies included cholecystectomy (47 of 571 patients).[32] The manoeuvres generally involve positive pressure ventilations, often in a Trendelenburg position, at the end of the procedure with the laparoscopic port valves open. The review concludes that the manoeuvre significantly decreases postoperative shoulder pain based on a 10 point VAS at 12 (MD − 1.55; 95%CI − 2.01 to − 1.10), 24 (MD − 1.59; − 2.00 to − 1.18) and 48 h (MD − 0.93; − 1.37 to − 0.50).[32]

The only other relevant study is a RCT (75 patients) which demonstrated active suction of insufflation gas via a port at the end of surgery reduced residual gas volume compared with no suction (6.7 vs. 15.9 ml, $p < 0.001$) and improved postoperative pain scores up to 48 h postoperatively.[33]

Summary/Recommendations

- Simple techniques at the end of the procedure to minimise residual pneumoperitoneum may improve postoperative pain and should be considered for use in routine LC. *(moderate-quality evidence, strong recommendation)*

Intraperitoneal Saline Instillation

The use of intraperitoneal saline solution has been postulated as an alternative intervention to intraperitoneal LA to improve postoperative outcomes.

A SR published in 2013 evaluated the use of both intraperitoneal saline and intraperitoneal LA instillation in preventing shoulder pain after LC and included data from 24 RCTs.[34] Of relevance, four of the trials assessed saline instillation versus no control, and 16 trials compared LA instillation versus saline as the control group. A significant reduction in the severity of shoulder pain was found for both saline and LA instillation individually, but notably there was no significant

advantage of LA over saline. However, the review does not perform a meta-analysis or report any numerical differences in pain scores and therefore the magnitude of effect or statistical significance cannot be determined. Furthermore, the protocols for saline instillation varied significantly with the volume ranging from a fixed 20–500 ml to a variable 25–30 ml/kg, or being combined with techniques of aspiration, drain placement or saline left in the abdomen. The possible mechanisms underlying the analgesic effects of saline solution include displacing subdiaphragmatic gas pockets, acting as an absorptive reservoir for residual carbon dioxide, providing lubrication for organ movement thereby preventing peritoneal irritation and diluting carbonic acid accumulated on peritoneal surfaces.[34] Using saline as an irrigant has the further advantage of avoiding any toxicity effects associated with LA instillation.

Summary/Recommendation

- Intraperitoneal instillation of saline appears safe and may be as effective as LA in reducing shoulder pain after LC so should be considered for use, although the optimal method is unclear *(moderate-quality evidence, weak recommendation).*

Routine Gallbladder Aspiration

Gallbladder perforation, with subsequent bile and gallstone spillage, may lead to infection/ intraperitoneal abscesses, postoperative ileus, excessive postoperative pain, adhesion formation and fistulae.[35] It is suggested that routine aspiration of the gallbladder during the procedure may be beneficial.

A single MA included two RCTs with 360 patients randomised to routine aspiration or no aspiration of the gallbladder.[35] The routine aspiration group were significantly less likely to have gallbladder perforation during surgery (risk ratio (RR) 0.42, 95%CI 0.19–0.96) but there were no differences in operative time, gallstone spillage, bleeding or 30-day infection rates.[35] The authors conclude that routine aspiration is safe and does not prolong operative time but acknowledging this does not translate into improved outcome.

Summary/Recommendations

- Routine aspiration of the gallbladder during uncomplicated LC does not offer any clinical benefit, is considered an unnecessary intervention and therefore not recommended as a routine practice. *(high-quality evidence, strong recommendation)*

Energy Source Use

Monopolar electrosurgery is the most widely used energy source in LC but advanced energy devices, including advanced bipolar or ultrasonic technology, are now also employed in routine cholecystectomy.

All three SRs relevant to this topic evaluated randomised trials comparing ultrasonic to electrosurgical energy sources.[36–38] The most recent and comprehensive of these, comprising 19 trials and 1955 patients, suggests the use of an ultrasonic energy device resulted in shorter operative time (MD -14.9 min; 95%CI -21.5 to -8.3, $p < 0.001$), less blood loss (-47.2 ml; -79.6 to -14.9, $p = 0.004$), less risk of intraoperative gallbladder perforation (RR 0.45; 95%CI 0.35–0.57, $p < 0.001$), shorter hospital stay (MD -0.37 days; -0.61 to -0.14, $p = 0.002$) and improved postoperative abdominal pain at 24 h (10 point VAS, MD -0.95; -1.40 to -0.50, $p < 0.001$).[38] The use of ultrasonic devices was associated with increased costs and elevated pro-inflammatory markers. Two earlier SRs identified similar improved outcomes with ultrasonic technology, but question their clinical importance and the financial implications of using a significantly more expensive device.[36, 37] A subsequent RCT, of 198 patients, found no significant differences between the ultrasonic and electrosurgery groups,[39] whilst another trial, of 280 patients, did demonstrate a lower rate of intraoperative gallbladder perforation with ultrasonic device use compared with monopolar electrocautery (8.6% vs 21.4%; $p = 0.002$) leading them to conclude its superiority although there were no other reported advantages to justify this conclusion.[40]

In cirrhotic patients undergoing LC, two RCTs have demonstrated the ultrasonic device is associated with less blood loss (70.13 vs 133 ml; $p = 0.02$ and 50 vs 120 ml; $p < 0.001$) and shorter operative time (45.17 vs 69.71 min; $p = 0.0001$ and 55 vs 82.5 min; $p < 0.001$) compared with monopolar use.[41, 42]

Summary/Recommendations

- Ultrasonic energy sources are as safe as monopolar electrosurgery in LC (including cirrhotic patients) and may result in better perioperative outcomes. These benefits should be balanced against their cost-effectiveness. *(high-quality evidence, weak recommendation)*
- There is no significant evidence evaluating other advanced energy sources such as advanced bipolar or combined ultrasonic/bipolar devices.

Imaging Techniques

Within the last 10 to 15 years, modern laparoscopic imaging technology, including high definition (HD) and three-dimensional (3D) vision, has evolved and is commonplace in the modern operating theatre.

The only SR evaluating imaging technique in LC is by Guruswamy et al. which compares 3D versus 2D imaging.[43] The authors identified only one trial (60 patients), which demonstrated no significant difference between the two groups in terms of operating time or number of errors. A subsequent and similar RCT assessed 3D versus 2D vision in laparoscopic surgery (cholecystectomy = 40 patients, appendicectomy = 39).[44] Although no objective clinical difference was identified, subjective assessment by the surgeon showed increased 'own felt safety' and improved 'task efficiency' when using 3D imaging. Another SR comparing 3D versus 2D vision, largely in the simulation environment, concluded that using 3D vision appears to reduce the number of errors and improve the speed of tasks.[45]

Summary/Recommendations

There is no evidence suggesting the superiority of any particular type of laparoscopic imaging for LC. *(moderate-quality evidence, weak recommendation)*

Cystic Duct Occlusion Method

Successful cholecystectomy requires safe occlusion and division of the cystic duct for which there are several methods including non-absorbable metal clips, absorbable clips, absorbable/ non-absorbable ligature, suture ligation and energy device sealing. There is no overwhelming consensus on which technique is best.

The only SR relating directly to this topic comprised three trials and 255 patients.[46] Two trials evaluated absorbable versus non-absorbable clips and the third trial compared absorbable ligatures and non-absorbable clips. Aside from a longer operative time (MD 12 min, 95%CI 1.6–22.4) for the absorbable ligature group (versus clips), there were no differences in outcomes; these findings were replicated in a subsequent 364 patient RCT.[47] The authors warn that because of the lack of trials, small sample sizes and short periods of follow-up, no reasonable conclusion can be made about the benefit or harm of any particular method of cystic duct occlusion. Another study, randomising 120 cirrhotic patients to ultrasonic device dissection and cystic duct closure or monopolar dissection with metal clip closure, did not show any difference in outcome and concluded that 'the [ultrasonic] scalpel provides complete haemobiliary stasis and is a safe alternative to the standard clipping of the cystic duct…'.[39] A prospective series of 125 patients, investigating ultrasonic sealing of the cystic duct showed no bile leaks and pressure testing of the cystic duct on the gallbladder side, demonstrated all specimens withstood at least 36 mmHg before leaking.[48]

Summary/Recommendations

- Ultrasonic sealing, metal clips, absorbable clips, suture ligation and ligature tie, as methods of cystic duct occlusion, have equipoise in postoperative outcomes, and all techniques may be considered for use. *(moderate-quality evidence, weak recommendation)*

Discussion

This review identifies ten areas of intraoperative technique in LC, which have high-quality evidence and for which recommendations can be made. Intraoperative techniques that demonstrate advantages in outcomes, and therefore can be recommended, are the use of LA (wound or IPLA), use of manoeuvres to reduce residual pneumoperitoneum and use of low-pressure pneumoperitoneum. There is good evidence for administering LA, but the optimal technique and the clinical relevance of any differences are uncertain. With relatively low postoperative pain scores already reported for elective LC, it is increasingly difficult to demonstrate further significant improvements. The only purpose of intraperitoneal insufflation is to allow surgical field exposure; all other effects of carbon dioxide insufflation are deleterious. But the simple measures of working at lower insufflation pressures (< 12 mmHg) and active suctioning or pulmonary recruitment ventilations at the end of surgery may minimise the negative effects of pneumoperitoneum. Importantly the accrued evidence shows that all these techniques have good safety profiles and therefore, regardless of the improvement magnitude, the risk/benefit ratio is clearly in favour of using these interventions. This review confirms that subhepatic drain placement and gallbladder aspiration do not confer any benefit in uncomplicated LC and therefore are not recommended practices. Of course, both techniques may still have a role in other settings where an emergent or 'hot' cholecystectomy is performed. The uses of warmed, humidified carbon dioxide, intraperitoneal saline instillation and advanced imaging techniques are examples of intraoperative technique which, despite some improvements in objective parameters, do not appear to translate into clear clinical efficacy. However, these interventions appear safe and the principle disadvantage is unnecessary cost. The remaining intraoperative interventions identified as having a notable evidence base are the type of energy source and methods to occlude the cystic duct. The evidence for both these topics confirms their non-inferiority compared with existing methods (e.g. using ultrasonic energy for dissection compared with monopolar electrosurgery) but may also represent publication bias. Any small improvements in outcomes should be balanced against the potential financial implications.

Uncomplicated, elective LC is achieved successfully with rapid postoperative recovery and without major complications in the majority of patients. However, as with any commonly performed operation, there are minor differences in the surgical steps and methods adopted by surgeons. Some of these variations in technique are suitable for developing an evidence-base and some are borne out of experience and heuristics and not amenable to the rigor of clinical trials. Optimisation of modifiable aspects of the LC procedure should improve outcomes and minimise morbidity. Conversely, unequivocally demonstrating the disadvantage for a particular variation may prevent unnecessary harm or cost. Finally, for the group of interventions for which there is no obvious superiority or inferiority, it is incumbent on the surgeon to use their own judgement for individual cases.

There are several limitations to this review. One weakness is the quality of the RCTs and SRs/ MAs on which the current review is based; many of the SRs have heterogeneity of data and many of the individual RCTs are underpowered leading to the probability of a type 2 error. A further limitation is being able to differentiate meaningful clinical improvements from statistically significant differences. This applies to outcomes including postoperative pain ratings or length of stay for which certain techniques demonstrate significant improvements but are so small they have no impact from a clinical perspective. Another issue is that a review which comprises only high-level evidence studies may omit practices which are not suitable for evaluation by SR or MA. For example, the use of the 'critical view of safety' concept is not suitable for RCTs (and subsequent MAs/ SRs), principally because of the large number of patients required to detect biliary injury, but is widely considered to be the gold standard method in avoiding biliary injury and improving outcomes. Furthermore, the laparoscopic approach has transformed recovery after cholecystectomy, compared with the open era, and postoperative morbidity rates have generally become very low. It is therefore becoming increasingly difficult to demonstrate any significant impact of relatively minor refinements on technique by means of traditional trial-based techniques such as RCTs. Assessing combinations of interventions that do not achieve statistical significance alone or adopting alternative approaches such as non-linear analysis or quality improvement science has the potential to address this issue.[49] Finally, because this is a review paper, the findings may not be considered novel as they have been previously published elsewhere. The studies may not have been particularly accessible individually but this paper brings together all the relevant evidence into a single review article which is a useful resource for any surgeon performing cholecystectomy.

Conclusion

This review of the existing high-level evidence highlights and suggests specific intraoperative techniques during uncomplicated LC that should be employed, avoided or considered by the individual surgeon. Optimising surgical technique in this way can lead to improved patient outcomes.

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Acquisition of data: S.W. and R.E.
Analysis and interpretation of data: S.W., W.L. and R.E.
Drafting and revising of the manuscript: S.W., W.L. and R.E.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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