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The impact of obesity on outcomes in patients undergoing emergency cholecystectomy for acute cholecystitis

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Abstract

Background: Obesity is a perceived risk factor for poorer surgical outcomes, including increased complication rates and mortality. As obesity rates rise annually, evaluating surgical outcomes in the obese population has become increasingly important. This study examines the impact of obesity on outcomes following emergency laparoscopic cholecystectomy (LC) for acute cholecystitis.
Methods: A retrospective review of patients who underwent emergency LC for acute cholecystitis between March 2018 and March 2021 was performed. A total of 326 patients were included and stratified by body mass index (BMI) into two groups: obese (BMI ≥30 kg/m^2, $n = 156$) and non-obese (BMI <30 kg/m^2, $n = 170$). Primary outcomes included length of stay, time to definitive surgery, and postoperative complications. Secondary outcomes included total operative time and intraoperative findings.
Results: Obese patients were younger than non-obese patients (median, 45 [34.3–56.8] and 48.5 [34.0–66.3] years; $p < 0.001$) and had a higher prevalence of diabetes (13.5% versus 6.5%; $p = 0.034$). Higher American Society of Anesthesiologists (ASA) classification ($p < 0.001$) and operative grading scores were observed in the obese group (76.3% versus 40.6%, $p < 0.001$), who were more likely to have a distended gallbladder (19.9% versus 11.2%, $p = 0.030$) and gallstone impaction (23.1% versus 11.8%, $p = 0.007$) in comparison to the non-obese group. Length of hospital stay, time to definitive surgery, and postoperative complication rates were similar between groups.
Conclusion: Although obesity is associated with greater technical difficulty during surgery than non-obese patients, similar postoperative outcomes were achieved. Obesity should not be a contraindication for LC and can be safely performed in the emergency setting.

Introduction

Obesity is defined by the World Health Organization as a body mass index (BMI) of 30 kg/m^2 or more.[1] In Australia, the prevalence of obesity amongst adults has increased from 19% in 1995 to 31% in 2018.[2] The rates of obesity are expected to continue rising and are predicted to reach 35% by 2025.[3] Obesity is associated with significant health consequences including cardiovascular disease, hypertension and diabetes.[4] Therefore, obesity is associated with increased morbidity and mortality compared to the general population.[4] In surgery, obesity is perceived as a risk factor for adverse post-surgical outcomes, including poorer prognosis and increased morbidity.[5]

Obesity is a well-established risk factor for gallstone formation.[6,7] Cholesterol stones are the most common gallstone type found in the obese population.[8] The formation of cholesterol stones in obesity is multifactorial and is primarily related to metabolic abnormalities associated with cholesterol hypersecretion by the liver.[7,8] This increase in cholesterol secretion is due to the activation of 3-hydroxy-3-methyl-glutaryl-coenzyme A (HMG-CoA) reductase, which is upregulated in obesity by hyperinsulinemia.[6–8] Gallstone formation is also accelerated by rapid weight loss following a very-low-calorie diet or after bariatric surgery.[7,8] Given these associations, obese individuals are more likely to have symptomatic gallstone disease requiring surgical management.[6,7]

Laparoscopic cholecystectomy (LC) is regarded as the gold standard treatment for acute cholecystitis.[9] Current literature suggests

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that LC in obese patients is associated with greater technical difficulty, increased conversion to open surgery, and higher surgical site infection rates.[10–12] Technical difficulty during LC in obese patients is related to the challenges associated with accessing the abdomen due to greater abdominal wall pannus and larger amounts of intra-abdominal fat which make it difficult to achieve adequate surgical exposure, as well as adhesions that arise from the inflammatory process of cholecystitis with adjacent viscera and fat.[5,12,13] These intraoperative findings make it more difficult to expose the anatomy of Calot's triangle, and consequently, conversion to open cholecystectomy may sometimes be necessary.[11,12,14] Other reasons for conversion during LC in obese patients include severe inflammation and necrosis of the gallbladder making laparoscopic dissection risky and unexpected bleeding.[14,15]

In this study, we review our experience with emergency LC in an obese cohort of patients undergoing surgery and compare this to the non-obese cohort to determine the safety of surgery in obese patients with acute cholecystitis.

Methods

Patient selection

A retrospective chart review was performed on patients ≥18 years who underwent emergency LC for acute cholecystitis at Queen Elizabeth II (QEII) Jubilee Hospital (Brisbane, Queensland) between March 2018 and March 2021. A total of 326 cases were included. Patients were divided into two groups according to their BMI and classified as obese (BMI ≥30 kg/m^2, $n = 156$) or non-obese (BMI <30 kg/m^2, $n = 170$) based on the World Health Organization definitions of obesity.[1] Ethics approval for the study was granted by the Metro South Health Human Research Ethics Committee (LNR/2019/QMS/56922; LNR/2020/QMS/62457).

All patients included met the Tokyo Guidelines 2018 (TG18) diagnostic criteria for acute cholecystitis.[16] A definitive diagnosis of acute cholecystitis was made if patients presented with clinical features indicative of local and systemic inflammation and imaging findings characteristic of acute cholecystitis. Imaging was performed using ultrasound or computed tomography. Patients were excluded if they were managed conservatively, underwent a delayed interval cholecystectomy, or had a cholecystectomy for a different primary indication than acute cholecystitis. Records missing height and weight measurements were also excluded.

Data collection

Patient data was retrieved from the Queensland Health integrated electronic medical record (ieMR) and tabulated into spreadsheet format using Microsoft Excel. Patient demographic information included sex, age, BMI, past medical history, smoking status, and American Society of Anesthesiologists (ASA) physical status classification. Preoperative factors such as presenting symptoms, initial laboratory results, and imaging findings were also included.

Intra-operative data on gallbladder appearance, distension or contracture of the gallbladder, ease of access, presence of sepsis in the peritoneal cavity, and the time taken to identify the cystic artery and duct was additionally collected to determine cholecystitis severity based on the 10-point operative scoring system developed by Sugrue *et al.*[13] The degree of operative difficulty was determined by the severity score calculated from these specific operative findings. A score of 0–1 was considered easy, 2–4, moderate, 5–7 difficult and 8–10, extreme. Postoperative complications were defined according to the Clavien-Dindo classification system.[17] Primary outcomes included length of hospital stay, time from admission to theatre, and postoperative complications. Secondary outcomes included total operative time, intraoperative characteristics, and rate of conversion to open cholecystectomy.

Statistical analysis

Data analysis was performed using SPSS® version 27.0 for Windows (IBM Corporation, New York, USA). Univariate analysis was performed using the χ^2 test for categorical variables and the student's t-test for continuous variables. Categorical variables were reported as percentages while continuous variables were presented as medians and interquartile ranges. For all comparisons, a p-value of <0.05 was considered statistically significant.

Results

Patient demographics and preoperative characteristics

A total of 326 patients underwent emergency LC for acute cholecystitis. There were 156 patients in the obese group and 170 patients in the non-obese group (47.9% versus 52.1%). Between the obese and non-obese groups, the BMI of patients varied significantly

Table 1 Comparison of patient characteristics between obese and non-obese groups

	No. of patients (%)		
	Non-obese $n = 170$	Obese $n = 156$	p-value(* $p < 0.05$)
Female	106 (62.4%)	109 (69.9%)	0.152
Age (years), median (IQR)	48.5 (34.0–66.3)	45 (34.3–56.8)	<0.001*
BMI (kg/m^2), median (IQR)	26 (24.0–28.1)	35 (32.2–39.2)	<0.001*
Comorbidities			
Ischemic heart disease	7 (4.1%)	2 (1.3%)	0.119
COPD	3 (1.8%)	2 (1.3%)	0.723
Hypertension	40 (23.5%)	37 (23.7%)	0.968
Diabetes mellitus	11 (6.5%)	21 (13.5%)	0.034*
Cerebrovascular disease	2 (1.2%)	3 (1.9%)	0.584
Chronic kidney disease	0	1 (0.6%)	0.296
Daily Smoker	35 (20.6%)	26 (16.7%)	0.364
Previous upper abdominal surgery	20 (11.8%)	11 (7.1%)	0.147

Abbreviations: COPD, chronic obstructive pulmonary disease; IQR, interquartile range. * indicates p<0.05.

Table 2 Comparison of preoperative characteristics between obese and non-obese groups

	No. of patients (%)		
	Non-obese $n = 170$	Obese $n = 156$	p-value(* $p < 0.05$)
Presentation factors			
Previous biliary colic	99 (58.2%)	93 (59.6%)	0.800
Symptom duration >72 h	38 (22.4%)	34 (21.8%)	0.903
RUQ tenderness	167 (98.2%)	155 (99.4%)	0.357
Murphy's positive	125 (73.5%)	104 (66.7%)	0.176
Palpable gallbladder	3 (1.8%)	2 (1.3%)	0.723
Fever	8 (4.7%)	13 (8.3%)	0.183
Tachycardia	10 (5.9%)	11 (7.1%)	0.668
Multi-organ involvement	4 (2.4%)	4 (2.6%)	0.902
Laboratory findings			
WCC $>10.8 \times 10^9$/L	95 (55.9%)	99 (63.5%)	0.164
Elevated CRP (≥9.0 mg/L)	54 (48.6%)	61 (62.2%)	0.049*
TG18 severity grade			0.863
Mild	122 (71.8%)	113 (72.4%)	
Moderate	44 (25.9%)	38 (24.4%)	
Severe	4 (2.4%)	5 (3.2%)	
ASA classification			<0.001*
1–2	145 (85.3%)	109 (69.9%)	
3–4	25 (14.7%)	47 (30.1%)	

Abbreviations: ASA, American Society of Anesthesiologists; CRP, C-reactive protein; RUQ, right upper quadrant; TG18, Tokyo Guidelines 2018; WCC, white cell count.
* indicates p<0.05

Table 3 Comparison of intraoperative and postoperative characteristics between obese and non-obese groups

	No. of patients (%)		
	Non-obese $n = 170$	Obese $n = 156$	p-value(* $p < 0.05$)
Time to theatre (hours), median (IQR)	25.3 (17.0–39.7)	27.3 (15.1–44.0)	0.739
Operation duration (minutes), median (IQR)	92 (67.0–132.0)	97 (72.3–133.0)	0.784
Operative findings			
GB adhesions <50%	32 (18.8%)	34 (21.8%)	0.505
GB adhesions >50%	34 (20.0%)	20 (12.8%)	0.082
Distended or contracted GB	19 (11.2%)	31 (19.9%)	0.030*
Unable to grasp GB	43 (25.3%)	27 (17.3%)	0.079
Adhesions from previous surgery	9 (5.3%)	5 (3.2%)	0.353
Impacted stone in Hartmann's pouch	20 (11.8%)	36 (23.1%)	0.007*
Bile or pus outside GB	14 (8.2%)	7 (4.5%)	0.168
Time to identify cystic artery and duct >90 min	70 (41.2%)	68 (44.2%)	0.578
Marked local inflammation	42 (24.7%)	38 (24.4%)	0.942
Operative grading score			<0.001*
Mild	101 (59.4%)	37 (23.7%)	
Moderate	43 (25.3%)	97 (62.2%)	
Severe	26 (15.3%)	22 (14.1%)	
Intraoperative factors			
Operative drain insertion	63 (37.1%)	55 (35.3%)	0.735
Haemorrhage >200 mL	1 (0.6%)	1 (0.6%)	0.296
Retained gallstones	10 (5.9%)	5 (3.2%)	0.249
Primary operator			0.715
Consultant	8 (4.7%)	5 (3.2%)	
Fellow	110 (64.7%)	106 (67.9%)	
Registrar	52 (30.6%)	45 (28.8%)	
Length of stay (days), median (IQR)	3 (2.0–4.0)	3 (2.0–3.8)	0.318
Conversion rate	0 (0%)	0 (0%)	
Bile duct injury	0 (0%)	0 (0%)	
Clavien-Dindo classification			0.851
Minor complication (I–II)	6 (3.5%)	5 (3.2%)	
Major complication (III–IV)	2 (1.2%)	3 (1.9%)	

Abbreviations: GB, gallbladder; IQR, interquartile range. * indicates p<0.05

(median, 35 [32.2–39.2] and 26 [24.0–28.1] kg/m^2; $p < 0.001$). Obese patients were younger (median, 45 [34.3–56.8] and 48.5 [34.0–66.3] years; $p < 0.001$) and had a higher prevalence of diabetes mellitus (13.5% versus 11%; $p = 0.034$) than non-obese patients.

Obese patients also had a higher ASA classification than non-obese patients with a greater proportion of patients having ASA scores ≥3 (30.1% versus 14.7%; $p < 0.001$). Furthermore, patients in the obese group were more likely to have an elevated C-reactive protein (CRP) greater than 9.0 mg/L than the non-obese controls

(62.2% versus 48.6%; $p = 0.049$). All other patient demographics and preoperative characteristics are reported in Tables 1 and 2.

Intraoperative and postoperative outcomes

Time to definitive surgery and total operation duration was comparable between groups with no significant differences. Intraoperatively, obese patients were more likely to have a distended or contracted gallbladder (19.9% versus 11.2%; $p = 0.030$) or gallstone impacted in Hartmann's pouch (23.1% versus 11.8%; $p = 0.007$) when compared to non-obese patients. Operative grading scores also differed significantly between groups with higher grading scores (moderate and severe) associated with obesity than non-obesity (76.3% versus 40.6%; $p < 0.001$).

Postoperatively, there were no significant differences found between the groups. Obese and non-obese patients were found to have similar postoperative complication rates (5.1% versus 4.7%; $p = 0.860$), and neither group required conversion to open surgery. The median length of hospital stay between obese and non-obese groups was 3 days for both groups (interquartile range [IQR] 2.0–3.8 and 2.0–4.0; $p = 0.318$). A comparison of all intraoperative and postoperative outcomes between obese and non-obese are listed in Table 3.

Discussion

In general, obesity introduces several challenges to operative management which can partly be attributed to the association between obesity and many comorbid conditions such as diabetes, hypertension, and cardiovascular disease.[18] As a consequence, obese patients require a thorough preoperative assessment before undergoing anaesthesia.[18] For example, patients with diabetes require careful monitoring before and after surgery as they are at an increased risk of postoperative complications, such as increased mortality if their disease is not well managed.[19,20] Furthermore, postoperative monitoring is often required in the obese as patients are more likely to develop respiratory complications following extubation.[21] These complications include acute respiratory failure, pneumonia, and prolonged mechanical ventilation.[22] Together, obesity and other patient comorbidities contribute to greater ASA physical classification scores, which help predict perioperative risk. As expected, obese patients in our study were more likely to have diabetes than those in the non-obese cohort. While patient comorbidities did not contribute to poorer outcomes following emergency LC, appropriate monitoring and greater utilization of hospital resources were likely required.

Interestingly in this study, CRP levels were higher in obese patients. CRP is an inflammatory marker used as a diagnostic criterion of acute cholecystitis in the revised Tokyo Guidelines 2018.[16] In a study by Bouassida *et al*., elevated CRP was predictive of acute cholecystitis of greater severity and increased rates of conversion to open surgery.[23] An association between obesity and elevated CRP levels have also been demonstrated in a study by Aronson *et al*.[24] Although neither group in this study required conversion to open surgery, these findings suggest obesity may mask the underlying inflammatory process leading to later presentation and hence more severe cholecystitis when presenting to explain the higher inflammatory marker.

This study also found that although obesity was associated with greater operative difficulty, emergency LC can be performed safely in the management of acute cholecystitis with similar postoperative outcomes achieved in both obese and non-obese groups. These findings are consistent with previous studies that evaluated the safety of elective LC in obese patients which found that obesity was not associated with higher complications after surgery in comparison to non-obese patients.[5,11,12,14,15,25,26] While the majority of studies reported no significant difference in conversion rates between groups, the study by Paajanen *et al*. found obesity was associated with a higher conversion rate (11.7% versus 6.1%, $p = 0.0003$) than non-obese patients.[11] In our experience, we believe that conversion to open surgery in an obese individual does not improve surgical exposure but may make the operation more labour intensive due to the large abdominal wall pannus that needs to be retracted and extensive packing that is required to expose the surgical field. Several studies reported that the duration of surgery in obese patients was significantly longer than that of the non-obese control group.[5,11,12,25,26] In our study, the obese cohort took a median of 5 min longer in operation duration however this difference did not reach statistical significance.

Several intraoperative grading scores have been developed to predict operative difficulty during LC. The operative grading system for cholecystitis severity developed by Sugrue *et al*. uses key surgical findings encountered during LC, such as access to the gallbladder, to predict operative difficulty.[13] In our study, obese patients had a higher operative grading score and were more likely to have a distended gallbladder or stone impacted in Hartmann's pouch. These findings may reflect a more severe inflammatory process observed in obese patients undergoing surgery for acute cholecystitis. It has been recognized that an impacted gallstone in Hartmann's pouch increases the operative difficulty of LC by causing severe oedema of the gallbladder wall that makes grasping and cephalad retraction difficult.[27] Large stones (≥1 cm) impacted in Hartmann's pouch also result in inflammatory processes around Calot's triangle. Inflammation increases the risk of bleeding and injury to the biliary tree when attempting to expose the critical view of safety and thus creates additional challenges to surgery.[27] These technical challenges can be overcome by decompression of the gallbladder to drain the bile which reduces the gallbladder oedema created by the tense mucocele.[28] Dislodgement of the stone can sometimes be attempted to improve grasping of the Hartmann's pouch, however, this may not always be possible in the event of severe inflammation. In these situations where safe dissection of Calot's triangle cannot be achieved, surgical strategies to circumvent bile duct injury may include conversion to open surgery to allow the use of fingers to aid tactile feedback when dissecting severely inflamed tissues. Together, these added manoeuvres add towards the operative time.[27,29,30]

Given the acute, high-risk nature of emergency operations, emergency general surgery patients are subject to higher rates of major postoperative complications and death when compared to those undergoing elective procedures.[31–33] These negative outcomes have been attributed to patient-specific factors including age, pre-existing comorbidities, and physiological abnormalities.[31,32] Despite these findings, emergency LC in acute cholecystitis allows for the offending source of infection to be removed quickly. Furthermore, the acute inflammatory response creates an oedematous plane between the gallbladder and the surrounding viscera, which helps facilitate dissection.[34] In contrast, elective surgery allows maturation of the associated inflammation, leading to the organization of dense adhesions and scarring of the gallbladder.[34] Dissection of the gallbladder under chronic inflammatory conditions is often more difficult and can lead to more postoperative complications.[35] To date, emergency LC has not resulted in poorer outcomes than elective LC for the management of acute cholecystitis.[36] Evaluating these outcomes more closely in the obese population is important as obesity was previously identified as a risk factor for conversion to open surgery in those undergoing emergency LC.[37] Interestingly, recent studies suggest obesity is protective against mortality in emergency abdominal operations.[38,39] Maloney *et al*. found that when stratified by weight, overweight and obese emergency surgical patients had a decreased risk of mortality compared to normal weight emergency surgery patients and underweight individuals had the highest risk of overall mortality.[38] Similar findings were reported by Benjamin *et al*., which found that only underweight and morbidly obese patients experienced greater postoperative complications.[39] It has been theorized that adipose tissue plays an immunomodulatory role in the sequestration and neutralization of endotoxins thus offering protection against mortality in obese patients undergoing emergency general surgery.[39]

Apart from the technical challenges that may present with operating on obese patients, favourable postoperative outcomes in this cohort can be achieved. In the cases where a consultant was unavailable, trainees received assistance from or were under the supervision of a surgical fellow. As such, when obese patients are operated on with due care and technical expertise, the risks are low.

While these findings provide insight into the surgical challenges and postoperative outcomes associated with obesity, this study has some limitations. First, as this is a single-institutional retrospective study, inherent biases and variability may exist. Second, given the relatively small sample size, conducting the same study in a larger population will help to confirm the effects of our study. Last, we acknowledge that there are differences in body proportions within the diverse Australasian population. Future studies should subdivide BMI into further classifications to account for these differences.

In conclusion, this study examines the safety of emergency LC in obese patients with acute cholecystitis. Although obesity was associated with greater technical difficulty during surgery, it did not lead to increased rates of conversion, postoperative complications, or mortality. Therefore, obesity should not be a contraindication for LC and is feasible in the emergency setting. Given that this was a single-centre retrospective study, expanding the study to include other institutions will help to increase the validity of these findings.

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Conflict of interest

None declared.

Author contributions

Alixandra Wong: Data curation; formal analysis; writing – original draft; writing – review and editing. **Sanjeev Naidu:** Writing – review and editing. **Raymond P. Lancashire:** Writing – review and editing. **Terence C. Chua:** Conceptualization; supervision; writing – original draft; writing – review and editing.

References

1. World Health Organization (WHO). *Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation*. Geneva: WHO, 2000.
2. Australian Institute of Health Welfare (AIHW). *Overweight and Obesity*. Canberra: AIHW, 2020.
3. Hayes AJ, Lung TWC, Bauman A, Howard K. Modelling obesity trends in Australia: unravelling the past and predicting the future. *Int. J. Obes. (Lond)* 2017; **41**: 178–85.
4. Blüher M. Obesity: global epidemiology and pathogenesis. *Nat. Rev. Endocrinol.* 2019; **15**: 288–98.
5. Simopoulos C, Polychronidis A, Botaitis S, Perente S, Pitiakoudis M. Laparoscopic cholecystectomy in obese patients. *Obes. Surg.* 2005; **15**: 243–6.
6. Cruz-Monserrate Z, Conwell DL, Krishna SG. The impact of obesity on gallstone disease, acute pancreatitis, and pancreatic cancer. *Gastroenterol. Clin. North Am.* 2016; **45**: 625–37.
7. Lammert F, Gurusamy K, Ko CW *et al*. Gallstones. *Nat. Rev. Dis. Primers.* 2016; **2**: 16024.
8. Erlinger S. Gallstones in obesity and weight loss. *Eur. J. Gastroenterol. Hepatol.* 2000; **12**: 1347–52.
9. Dittrick GW, Thompson JS, Campos D, Bremers D, Sudan D. Gallbladder pathology in morbid obesity. *Obes. Surg.* 2005; **15**: 238–42.
10. Winfield RD, Reese S, Bochicchio K, Mazuski JE, Bochicchio GV. Obesity and the risk for surgical site infection in abdominal surgery. *Am. Surg.* 2016; **82**: 331–6.
11. Paajanen H, Käkelä P, Suuronen S, Paajanen J, Juvonen P, Pihlajamäki J. Impact of obesity and associated diseases on outcome after laparoscopic cholecystectomy. *Surg. Laparosc. Endosc. Percutan. Tech.* 2012; **22**: 509–13.
12. Afaneh C, Abelson J, Rich BS *et al*. Obesity does not increase morbidity of laparoscopic cholecystectomy. *J. Surg. Res.* 2014; **190**: 491–7.
13. Sugrue M, Sahebally SM, Ansaloni L, Zielinski MD. Grading operative findings at laparoscopic cholecystectomy- a new scoring system. *World J. Emerg. Surg.* 2015; **10**: 14.
14. Farkas DT, Moradi D, Moaddel D, Nagpal K, Cosgrove JM. The impact of body mass index on outcomes after laparoscopic cholecystectomy. *Surg. Endosc.* 2012; **26**: 964–9.
15. Ammori BJ, Vezakis A, Davides D, Martin IG, Larvin M, McMahon MJ. Laparoscopic cholecystectomy in morbidly obese patients. *Surg. Endosc.* 2001; **15**: 1336–9.
16. Yokoe M, Hata J, Takada T *et al*. Tokyo guidelines 2018: diagnostic criteria and severity grading of acute cholecystitis (with videos). *J. Hepatobiliary Pancreat. Sci.* 2018; **25**: 41–54.
17. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann. Surg.* 2004; **240**: 205–13.

18. Carron M, Safaee Fakhr B, Ieppariello G, Foletto M. Perioperative care of the obese patient. *BJS* 2020; **107**: e39–55.
19. Rehman H-u, Mohammed K. Perioperative management of diabetic patients. *Curr. Surg.* 2003; **60**: 607–11.
20. Nguyen NT, Varela JE. Bariatric surgery for obesity and metabolic disorders: state of the art. *Nat. Rev. Gastroenterol. Hepatol.* 2017; **14**: 160–9.
21. Domi R, Laho H. Anesthetic challenges in the obese patient. *J. Anesth.* 2012; **26**: 758–65.
22. Hodgson LE, Murphy PB, Hart N. Respiratory management of the obese patient undergoing surgery. *J. Thorac. Dis.* 2015; **7**: 943–52.
23. Bouassida M, Zribi S, Krimi B *et al*. C-reactive protein is the best biomarker to predict advanced acute cholecystitis and conversion to open surgery. A prospective cohort study of 556 cases. *J. Gastrointest. Surg.* 2020; **24**: 2766–72.
24. Aronson D, Bartha P, Zinder O *et al*. Obesity is the major determinant of elevated C-reactive protein in subjects with the metabolic syndrome. *Int. J. Obes. (Lond)* 2004; **28**: 674–9.
25. Enami Y, Aoki T, Tomioka K *et al*. Obesity is not a risk factor for either mortality or complications after laparoscopic cholecystectomy for cholecystitis. *Sci. Rep.* 2021; **11**: 2384.
26. Sidhu RS, Raj PK, Treat RC, Scarcipino MA, Tarr SM. Obesity as a factor in laparoscopic cholecystectomy. *Surg. Endosc.* 2007; **21**: 774–6.
27. Khan KS, Sajid MA, McMahon RK, Mahmud S, Nassar AHM. Hartmann's pouch stones and laparoscopic cholecystectomy: the challenges and the solutions. *JSLS* 2020; **24**: e2020.00043.
28. Saber AA, Rosin D, Brasesco OE, Avital S, Rosenthal RJ. A simple technique for decompression of distended gallbladder during laparoscopic cholecystectomy. *Surg. Endosc.* 2002; **16**: 718–9.
29. Lee W, Jang JY, Cho J-K, Hong S-C, Jeong C-Y. Does surgical difficulty relate to severity of acute cholecystitis? Validation of the parkland grading scale based on intraoperative findings. *Am. J. Surg.* 2020; **219**: 637–41.
30. Griffiths EA, Hodson J, Vohra RS *et al*. Utilisation of an operative difficulty grading scale for laparoscopic cholecystectomy. *Surg. Endosc.* 2019; **33**: 110–21.
31. Havens JM, Peetz AB, Do WS *et al*. The excess morbidity and mortality of emergency general surgery. *J. Trauma Acute Care Surg.* 2015; **78**: 306–11.
32. Akinbami F, Askari R, Steinberg J, Panizales M, Rogers SO. Factors affecting morbidity in emergency general surgery. *Am. J. Surg.* 2011; **201**: 456–62.
33. Scott JW, Olufajo OA, Brat GA *et al*. Use of national burden to define operative emergency general surgery. *JAMA Surg.* 2016; **151**: e160480-e.
34. Kolla SB, Aggarwal S, Kumar A *et al*. Early versus delayed laparoscopic cholecystectomy for acute cholecystitis: a prospective randomized trial. *Surg. Endosc.* 2004; **18**: 1323–7.
35. Borzellino G, Khuri S, Pisano M *et al*. Timing of early laparoscopic cholecystectomy for acute calculous cholecystitis: a meta-analysis of randomized clinical trials. *World J. Emerg. Surg.* 2021; **16**: 16.
36. Lyu Y, Cheng Y, Wang B, Zhao S, Chen L. Early versus delayed laparoscopic cholecystectomy for acute cholecystitis: an up-to-date meta-analysis of randomized controlled trials. *Surg. Endosc.* 2018; **32**: 4728–41.
37. Rosen M, Brody F, Ponsky J. Predictive factors for conversion of laparoscopic cholecystectomy. *Am. J. Surg.* 2002; **184**: 254–8.
38. Maloney SR, Reinke CE, Nimeri AA *et al*. The obesity paradox in emergency general surgery patients. *Am. J. Surg.* 2021.
39. Benjamin ER, Dilektasli E, Haltmeier T, Beale E, Inaba K, Demetriades D. The effects of body mass index on complications and mortality after emergency abdominal operations: the obesity paradox. *Am. J. Surg.* 2017; **214**: 899–903.