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Review

Bedside Laparoscopy in the Critically Ill: A Review of the Literature

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Abstract: Critically ill patients treated in the intensive care unit (ICU) can present many abdominal conditions that need a prompt diagnosis and timely treatment because of their general frailty. Clinical evaluation and diagnostic tools like ultrasound or CT scan are not reliable or feasible in these patients. Bedside laparoscopy (BSL) is a minimally invasive procedure that allows surgeons to assess the abdominal cavity directly in the ICU, thus avoiding unnecessary exploratory laparotomy or incidence related to intra-hospital transfer. We conducted a review of the literature to summarize the state-of-the-art of BSL. Medline, The Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus databases were utilized to identify all relevant publications. Indications, contraindications, technical aspects, and outcomes are discussed. The procedure is safe, feasible, and effective. When other diagnostic tools fail to diagnose or exclude an intra-abdominal condition in ICU patients, BSL should be preferred over exploratory laparotomy.

Keywords: bedside laparoscopy; minimally invasive surgery; critically ill patients

Introduction

Critically ill patients treated in the intensive care unit (ICU) can present many abdominal conditions [1] that need a prompt diagnosis and timely treatment because of their general frailty. Clinical evaluation is not always reliable due to sedation or analgesia. In some cases, it can be misleading, causing a delayed diagnosis, which can be detrimental to this category of patients [2]. Furthermore, the accuracy of diagnostic tests such as ultrasound or CT scan is reduced. In particular, ultrasound benefits from patient compliance and is operator dependent [3], while CT scan requires intra-hospital transportation with its established rates of related complications and mortality [4,5]. These include patient-related or equipment-related adverse events such as hypotension, respiratory distress, dysrhythmias, central line disconnections, oxygen supply problems, or accidental extubation.

Given the physiological derangement of ICU patients, the impaired physical examination, the reduced accuracy of diagnostic tests, and the time-dependency imposed by these situations, the treatment of choice - when a diagnosis has not been established - has historically been the exploratory laparotomy. To date, there are no data regarding the rate of positive intra-abdominal findings at exploratory laparotomy in critically ill patients. Nonetheless, negative laparotomy is a reality surgeons encounter in their practice, and some reports on other types of patients [6–9] suggest that his rate and associated comorbidities are far from negligible.

Bedside laparoscopy (BSL) is a minimally invasive procedure that allows surgeons to assess the abdominal cavity directly in the ICU, thus avoiding unnecessary exploratory laparotomy or incidence related to intra-hospital transfer.

The present review summarizes the state-of-the-art of BSL.

Materials and Methods

We searched through Medline, The Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus databases using these terms: “bedside laparoscopy”, “diagnostic laparoscopy”, “critically ill”, “ICU”, and “intensive care unit”. MeshTerms were included. We also conducted a hand-search of references of previous reviews on the same topic to include all relevant studies.

Indications and contraindications

The physiological consequences of pneumoperitoneum, especially in critically ill patients, allow only for brief and basic operations as they may outweigh the benefits of BSL in case of time-consuming or technically challenging procedures [10,11]. Therefore, BSL should be primarily used to recognize intra-abdominal pathology not identified by other diagnostic tools or to perform short and simple operations such as controlling minor bleeding or placing a drain. By following these recommendations, BLS can effectively lower the rate of unnecessary exploratory laparotomy while the instrumentation requirements and the possible complications are kept at a minimum.

The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guidelines state that the indications for diagnostic laparoscopy in acute conditions in which a diagnosis has not been established are trauma, acute abdominal pain, and ICU patients [12]. In the first two categories, diagnostic laparoscopy is used only in hemodynamically stable patients [13]; hence, the procedure is generally performed in the operating room. Conversely, for critically ill patients, BSL can and should be conducted in the ICU for the following reasons:

1. Unexplained sepsis, systemic inflammatory response syndrome, or multiorgan failure.
2. Abdominal pain or tenderness associated with other signs of sepsis without an obvious indication for laparotomy.
3. Increased abdominal distention that is not a consequence of bowel obstruction.
4. Fever or leukocytosis in an obtunded or sedated patient not explained by another identifiable problem.
5. Metabolic acidosis not explained by another process.

While BSL represents an effective tool in the diagnostic process in the situations mentioned above, surgeons should bear in mind that it is still an invasive procedure with well-known cardiac and respiratory consequences in an already frail population. Thus, a thorough patient selection is mandatory. When planning a BSL, the following contraindications should be considered:

1. Patients unable to tolerate pneumoperitoneum or who are so critical that have no chance of survival even if a treatable intra-abdominal pathology is found.
2. Patients with an already established diagnosis requiring surgical intervention.
3. Patients with uncorrected coagulopathy or hypercapnia.
4. Patients with suspected abdominal compartment syndrome.
5. Recent laparotomy in the last 4-6 weeks.
6. Intra-abdominal adhesions secondary to previous surgical interventions (relative).

Instrumentation and setting

As mentioned above, the severe clinical conditions faced by most patients admitted to the ICU force BSL to be a concise and straightforward procedure. Therefore, the required instrumentation reflects this necessity. In the published series [14–24], surgeons utilized a basic laparoscopic set including a monitor, an insufflator, and a light source, all placed on a dedicated mobile tower stored in the ICU, a 30° scope, a light cord, a Hasson trocar (10-12 mm) and two 5 mm trocars, manipulating instruments, and standard sterile dressing and drapes. The procedure was conducted in an isolated single bedroom in the ICU ward. All the staff in the room - consisting of an anesthesiologist, a surgeon and an assistant, one nurse from the operating room, and one ICU nurse - wore protective clothing,

surgical masks and caps, and gloves. Standard operating room protocols were meticulously followed to ensure sterility.

Anesthesiological technique

Eight of the included studies reported details on the anesthesiological technique [14–18,21–24]. An anesthesiologist directed general anesthesia induction, mechanical ventilation, and hemodynamic support of the patients during the procedure in all cases except for Karasakalides et al. and Kelly et al.'s work [18,24], in which the ICU nurse was responsible for patient monitoring. The vast majority of patients were already intubated. Patients not requiring mechanical ventilation were generally intubated just before the procedure. Only Pecoraro et al. did not insert an endotracheal tube in patients not artificially ventilated before BSL [22]. General anesthesia was performed in a total intravenous fashion via a bolus of propofol, midazolam, ketamine, and remifentanyl or fentanyl. Neuromuscular blockade was achieved with either atracurium or cisatracurium. When needed, hemodynamic support was ensured with noradrenaline or dobutamine infusion.

Surgical technique

Patients were placed in their ICU bed in a supine position; Trendelenburg and anti-Trendelenburg inclinations were used to explore the entire abdominal cavity. A standard surgical field, with abdominal prepping and surgical dressing and drapes, was created following operating room protocols. The pneumoperitoneum was achieved using an open Hasson technique with a 10-12 mm trocar placed in the paraumbilical region. However, the suspected presence of intra-abdominal adhesions should dictate the placement of the first trocar, aiming for a so-called “virgin” site to minimize the risk of hollow viscus injury. Only Jaramillo et al. used a Veress needle to insufflate the abdominal cavity [16].

When reported, intra-abdominal pressure was generally maintained between 8 and 10 mmHg to minimize the physiological consequences of pneumoperitoneum, especially with concerns about hemodynamic instability in an already compromised population. Peris et al. reported pressure of 8 to 15 mmHg [15], while Walsh et al. set intra-abdominal pressure at 15 mmHg [17]. Once the pneumoperitoneum was established, two additional 5 mm trocars were generally placed. These two additional working ports were often inserted “as needed” without a standardized technique. Alemanno et al. reported the insertion of two 5 mm trocars in the left part of the abdomen to explore the right quadrants and two 5 mm trocars on the right part of the abdomen to explore the left quadrants [14], while Hackert et al. and Bergamini et al. used two 5 mm trocars in the left and right lower quadrants [19,21].

Patients characteristics and outcomes

In the included studies [14–25], 399 patients underwent BSL. The most frequent ICU admission diagnosis was by far post-cardiac surgery monitoring with 202 cases (50.6% of patients), followed by sepsis (68 cases), trauma (41 cases), vascular surgery (16 cases), respiratory failure (12 cases), cardiogenic shock (12 cases), and some other less frequent etiologies. Patients characteristics of the included studies are summarized in Table 1. These results are partly biased because of the studies by Hackert et al. [19] and Bergamini et al. [21], which enrolled only patients admitted to the ICU after a cardiac surgery procedure. Nonetheless, gastrointestinal complications after cardiac surgery are rare but devastating occurrences often burdened by serious clinical sequelae and high mortality rates, with incidence rates ranging from <1% to 4.1 % and mortality rates between 13.9% and 63% [26,27]. In a retrospective analysis of 4819 patients undergoing cardiac surgery, Filsoufi et al. found age, myocardial infarction, congestive heart failure, hemodynamic instability, cardiopulmonary bypass time >120 minutes, peripheral vascular disease, renal and hepatic failure as independent predictors of gastrointestinal complications [28].

Table 1. Summary of the included studies.

Study	Year	Patients	Admission diagnosis (n)	Positive findings (%)	Diagnosis (n)	Unnecessary laparotomy avoided (%)	Treatment (n)	Mortality (BSL +)
Alemanno [14]	2019	129	Cardiac surgery (90) Sepsis (25) Trauma (14)	69 (53.5)	Bowel ischemia (40) Bowel hypoperfusion (6) Cholecystitis (13) Bowel perforation (2) Purulent peritonitis (4) Other (4)	55.0	Operative (58) Conservative (6) Palliative (5)	40.6
Peris [15]	2009	32	Cardiac surgery (6) Sepsis (12) Trauma (14)	15 (46.8)	Bowel ischemia (1) Bowel perforation (2) Bowel hypoperfusion (2) Purulent peritonitis (3)	75.0	Operative (8) PGBD (5) Conservative (2)	33.3
Jaramillo [16]	2006	13	Sepsis (7) MOF (1) Acute myocardial infarction (2) Intestinal obstruction (1) Bowel ischemia (2) Cardiac surgery (1) Cardiac (not surgery) (3)	9 (69.2)	Bowel ischemia (6) Bowel perforation (1) Cholecystitis (2)	/	Operative (2) Palliative (7)	77.8
Walsh [17]	1998	12	Sepsis (5) Respiratory failure (2) Aortic occlusion (1) Trauma (5) Respiratory failure (9) Cardiogenic shock (8) Sepsis (11)	5 (41.6)	Bowel ischemia (2) Sigmoid diverticulitis (1) Terminal ileitis (1) Non-purulent peritonitis (1) Bowel ischemia (6) Cholecystitis (5) Biliary peritonitis (1) Purulent peritonitis (2)	91.6	Operative (1) Palliative (4)	80.0
Karasakalides [18]	2009	35	Cerebral hemorrhage (2)	15 (42.8)	Mesenteric hemorrhage (1) Bowel ischemia (6) Bowel distension (4) Acute cholecystitis (3) Fibrinous peritonitis (1) Acute pancreatitis (1)	82.8	Operative (11) Palliative (4)	60.0
Hackert [19]	2003	17	Cardiac surgery (17)	15 (88.2)	Bowel ischemia (7) Cholecystitis (2) Liver ischemia (2) Acute pancreatitis (1) Gangrenous uterus (1) Gastric volvulus (1)	/	Operative (14) Conservative (1)	53.3
Sajid [20]	2018	28	/	14 (50.0)	Bowel ischemia (13) Duodenal perforation (1) LUQ abscess (1) Large pelvic mass (1) Cirrhosis (1) Bowel ischemia (1) Colo-vesical fistula (1)	82.1	Operative (8) Conservative (3) Palliative (3)	/
Bergamini [21]	2022	43	Cardiac surgery (43) Sepsis (4) Intestinal perforation (3)	13 (30.2)	Bowel ischemia (13) Duodenal perforation (1) LUQ abscess (1) Large pelvic mass (1) Cirrhosis (1) Bowel ischemia (1) Colo-vesical fistula (1)	69.7	/	46.1
Pecoraro [22]	2001	11	Bowel ischemia (1) Thoracic surgery (1) Diabetic ketoacidosis (1) Jaundice (1)	6 (54.5)	Bowel ischemia (13) Duodenal perforation (1) LUQ abscess (1) Large pelvic mass (1) Cirrhosis (1) Bowel ischemia (1) Colo-vesical fistula (1)	63.6	Operative (4) Percutaneous drainage (1) Conservative (1)	50.0
Ceribelli [23]	2012	62	Cardiac surgery (38) Vascular surgery (13) Trauma (6) Sepsis (3) Neurosurgery (2)	43 (69.3)	Cholecystitis (29) Bowel ischemia (5) Diaphragmatic rupture (3) Perforated peptic ulcer (2)	30.6	Operative (43)	48.8

It is also to be noted that in 11 cases, BSL was able to find peritonitis, either fibrinous or purulent, without an apparent underlying cause. It can be inferred that, in these 11 patients, the peritonitis had an unidentified origin and that BSL was inconclusive or nondiagnostic rather than considering them as cases of “spontaneous” peritonitis.

BSL vs. CT scan

A suspected intra-abdominal pathology in an already compromised population, such as the ICU patients, should not be underestimated because, if not treated swiftly, it could lead to a rapid and severe worsening of the clinical conditions and, in some cases, to death. It is generally investigated with a radiological examination, such as a CT scan of the abdomen, although this technique has different sensitivity and specificity rates for each possible cause. For example, Menke, in his meta-analysis, studied the accuracy of CT in detecting acute mesenteric ischemia for all causes, showing a pooled sensitivity of 93% and a pooled specificity of 95% [29]. When considering the use of abdominal CT scan in patients undergoing cardiac surgery, which represents the most common admission diagnosis in patients undergoing BSL, it should be remembered that the most frequent cause of acute mesenteric ischemia is non-occlusive mesenteric ischemia (NOMI) given the impaired cardiac output peculiar to this group of patients, with rates ranging from 48% to 83% [30,31]. Despite the great accuracy demonstrated by CT scan in detecting acute mesenteric ischemia for all causes, when evaluating only NOMI, CT scan is not as efficient and could potentially underestimate an ongoing ischemic injury [32,33].

Although CT scan has been traditionally thought to be less sensitive than ultrasound for diagnosing acute cholecystitis [34], recent data finds CT scan is more reliable in detecting acute cholecystitis [35]. However, in critically ill patients, the most common cause of acute cholecystitis is acalculous cholecystitis, a clinical entity of which the diagnostic accuracy of CT scan has yet to be studied.

Given that the two most common positive findings at BSL are acute mesenteric ischemia and acute cholecystitis and that the most common underlying causes of these two clinical entities in critically ill patients are NOMI and acute acalculous cholecystitis, it is safe to assume that in this subgroup of patients CT scan has lower efficiency. In a 2015 study by Just et al. analyzing the role of CT scan in identifying a potential infectious source in critically ill patients, CT scan detected an infectious source in 52.8% of cases, resulting in a change in treatment in 85.5% of cases. Conversely, treatment was changed in 16.2% of cases in patients without identification of an infectious source. In their conclusions, the Authors called for a more careful and standardized use of CT scan in ICU patients [36]. In their clinical practice, when evaluating intra-abdominal pathologies in critically ill patients, surgeons should bear in mind the lower accuracy of CT scan and consider BSL in case of an inconclusive clinical examination and radiology.

5. Conclusions

The present review summarizes the state-of-the-art of BSL. The procedure is safe, feasible, and effective. When other diagnostic tools fail to diagnose or exclude an intra-abdominal condition in ICU patients, BSL should be preferred over exploratory laparotomy.

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