Medical Research Archives

European Society of Medicine

OPEN ACCESS

Published: August 31, 2023

Citation: Ribeiro MAF, Tebar GK, et al., 2023. Role and Limitations of Laparoscopy in Abdominal Trauma, Medical Research Archives, [online] 11(8). https://doi.org/10.18103/mra.v11i8.4333

DOI
https://doi.org/10.18103/mra.v11i8.4333

ISSN: 2375-1924

RESEARCH ARTICLE

Role and Limitations of Laparoscopy in Abdominal Trauma

Marcelo A. F. Ribeiro Jr.*[,1] MD, MSc, PhD, FACS; Gabriela Karabachian Tebar[2] MD; José Lucas Rodrigues Salgueiro[2]MD, Gabriel Franco de Camargo Galindo[2]MD, Joy D. Hughes[3] MD, Ahmed Al Sayari[3] MD, Erik Scott De Soucy[3] DO, Shahin Mohseni[3] MD

[1]- Professor of Surgery. Professor of General and Trauma Surgery at Catholic University of São Paulo – PUCSP-Sorocaba; Professor of Surgery at Khalifa University and Gulf Medical University UAE. Chair & Consultant Division of Trauma, Critical Care and Acute Care Surgery at Sheikh Shakhbout Medical City – Abu Dhabi – UAE. Chairman of the Education Committee of the Panamerican Trauma Society, Associate Member of the ACS Academy of Master Surgeon Educators.
[2]- Former Residents of General Surgery at Catholic University of São Paulo – PUCSP-Sorocaba
[3]- Consultant Division of Trauma, Critical Care and Acute Care Surgery at Sheikh Shakhbout Medical City – Abu Dhabi – UAE.

***Corresponding Author:** drmribeiro@gmail.com

ABSTRACT
Trauma surgery is traditionally carried out through open procedures; however, the use of laparoscopy in stable patients has been gaining room due to favorable outcomes reported in different studies available in the literature. Nowadays, laparoscopy applied to trauma cases can be divided into screening, diagnosis, and therapeutic applications. Laparoscopic surgery application was initially limited to screening procedure focused on finding peritoneal violations; such a procedure would be followed by exploratory laparotomy. The benefits of using laparoscopy in trauma cases as diagnostic tool to rule out intra-abdominal injuries that may have gone unnoticed in computed tomography, such as diaphragmatic injuries can be easily seen. It can be used to prevent unnecessary laparotomies in patients with penetrating injuries, whose fascial breach cannot be clinically or radiologically ruled out. This paper describes the current indications for the use of laparoscopy in trauma, its potential benefits as well as complications related to the technique. We highlight and describe the importance of systematization for investigation of the peritoneal cavity as well as the expansion of indications for treatment of certain lesions by exclusive laparoscopic approach. This is due to the development of equipment as well as a greater number of surgeons trained in advanced laparoscopic surgery. We also present the main potential complications related to the method as well as the limitations still encountered today.

Keywords: Trauma, laparoscopy, therapeutic use, hemodynamics, radiography, tomography, injury

Introduction

Laparoscopic surgery stopped being an innovative technology to become standard procedure in many surgical specialties. Its recommendation for trauma patients presenting hemodynamically stable condition has been progressively expanded. Nowadays, improvements observed in the laparoscopic equipment and surgical technique have decreased the rate of lesions that used to go unnoticed during laparoscopic surgeries from 13% to 0.12%[1]. Trauma surgery is traditionally carried out through open procedures; however, the use of laparoscopy in stable patients has been gaining room due to favorable outcomes reported in different studies available in the literature[2]. According to the literature negative laparotomies may lead to around 40% of postoperative complications such as abdominal wall dehiscence, hernias, surgical site infections, intraabdominal adhesions and intestinal obstructions and even death[3].

The hemodynamic stability of trauma patients is the basic condition for video laparoscopic surgery recommendation; this group also includes patients whose condition has stabilized after fluid resuscitation. Computed tomography is often held before laparoscopy in order to increase surgical accuracy and to avoid unnecessary procedures[4].

Nowadays, laparoscopy applied to trauma cases can be divided into screening, diagnosis and therapeutic applications. Laparoscopic surgery application was initially limited to screening procedure focused on finding peritoneal violations; such a procedure would be followed by exploratory laparotomy. Diagnostic laparoscopy (DL) goes beyond screening, since it is used to fully assess patients' peritoneal cavity in a systematic and meticulous way. It can be used as diagnostic tool to rule out intra-abdominal injuries, such as the diaphragmatic ones, which may have gone unnoticed during computed tomography. Therapeutic laparoscopy (TL) application to trauma cases is reported as viable and safe, as long as the hospital provides proper material and experienced surgeon to perform the procedure. Procedures that do not identify injuries, or that the identified injuries do not require repair, are defined as non-therapeutic DL[1,5].

Laparoscopy has been widely used in the current scenario to treat penetrating trauma, given its sensitivity, specificity and accuracy close to 100%[4]. However, laparoscopy using to treat blunt abdominal trauma is not yet fully defined. Although several diagnostic methods are available to assess trauma patients, intra-abdominal injury diagnosis remains a challenge in clinical practice, mainly diaphragm, mesentery and small bowel injuries[6].

Non-invasive diagnostic imaging methods can be used at initial penetrating trauma assessment, and computed tomography is among them, although it presents major limitations to assess diaphragmatic injuries. According to estimates, the aforementioned methods can only evidence diaphragmatic injuries in 26 % of cases. Patients with gastrointestinal and pancreatic tract injuries, who undergo non-therapeutic laparotomy procedures based on these non-invasive diagnostic imaging methods, may present high morbidity and mortality rates. Laparoscopy can avoid non-therapeutic laparotomy in 63% of cases[7].

Indications and Contraindications

The benefits of using laparoscopy in trauma cases as diagnostic tool to rule out intra-abdominal injuries that may have gone unnoticed in computed tomography, such as diaphragmatic injuries can be easily seen. It can be used to prevent unnecessary laparotomies in patients with penetrating injuries, whose fascial breach cannot be clinically or radiologically ruled out. Furthermore, laparoscopy can play important therapeutic role when the physician in charge of conducting it has the right surgical skills[2,8].

Table 1. Laparotomy recommendations for trauma cases

Laparotomy recommendations for trauma cases	Suspected issue
Clinical peritonitis or pneumoperitoneum	It is indicative of gastrointestinal injury
Inconclusive findings in imaging methods	Suspected gastroduodenal, colorectal or bladder injuries
"Unclear abdomen"	Discrepancy between imaging findings and physical examination
Penetrating abdominal trauma	Doubts about whether there was peritoneal penetration, or not
Penetrating trauma in thoracoabdominal transition	Suspected diaphragmatic tear

Among the laparoscopy recommendations in trauma scenarios, one can mention (Tablel 1)[7]:

- Hemodynamic Hemodynamic stability: grades I and II shock (rapid response to fluid resuscitation) with blunt or penetrating injuries to the abdomen that would require otherwise open exploration

- Peritonitis: it is historically contraindicated due to potential risk of hypercapnia in severe intraabdominal infection cases, as well as to risk of toxic shock syndrome caused by high intraperitoneal pressure. Such a controversial issue has been investigated in recent decades and studies have shown adequate benefits deriving from laparoscopy performed in peritonitis cases.

- CT findings and diagnostic uncertainty: diagnostic and potentially therapeutic laparoscopy is a valuable diagnostic tool in suspected gastroduodenal, colorectal or intraperitoneal bladder injuries.

- Trauma of large vessels, and retroperitoneal and renal injuries can be laparoscopically investigated or diagnosed, but only highly selected cases should be explored and treated. Open surgery remains the best way to manage retroperitoneal traumas.

- "Unclear abdomen": discrepancy between image finding and physical examination results.

- Unexplained trauma with free fluid in the cavity and no damage to solid organs.

- Suspected or image-confirmed mesenteric injury (free fluid, hematoma and/or densification of adipose planes).

- Penetrating abdominal trauma with uncertain peritoneal penetration. Digital exploration can be initially performed, but it must be carried out by experienced surgeon based on the appropriate technique. Laparoscopy can be performed in healthcare institutions lacking experience in non-operative treatments; in case of negative results, patients can be discharged early. However, early diagnosis without sepsis and contamination means better chances of primary repair and better outcome in hollow viscus injury cases.

- Clinical peritonitis or pneumoperitoneum: it suggests gastrointestinal injury; thus, laparoscopy can be used to diagnose and treat it, depending on the injury and on the surgeon's skill.

- Intraperitoneal bladder injury: cases presenting intraperitoneal leakage at cystography or cases with unexplained free fluid may benefit from laparoscopy.

- Penetrating trauma in the thoracoabdominal transition: suspected diaphragmatic tear after penetrating trauma. It comprises cases of splenic trauma eligible for non-operative treatment used to assess patients' diaphragm, which may be injured in approximately 30% of cases.

- Penetrating trauma presenting evisceration.

- Splenic trauma associated with failure in, or contraindication of, angioembolization in stable patients. Video laparoscopic splenectomy can be performed.

- High-grade liver trauma can show complications and the laparoscopic treatment may be indicated for hemoperitoneum or choleperitoneum drainage, infectious perihepatic collection and biliary peritonitis treatment.

- Pancreatic trauma: exploration, hemostatic agent placement, as well as laparoscopic evacuation of peripancreatic fluid collection and drainage may be alternative approaches to treat this trauma[7].

Table 2. Absolute contraindications and Relative contraindications for laparoscopy

Absolute contraindications	**Relative contraindications**
Hypovolemic shock	Umbilical or diaphragmatic hernia
Impossibility of performing pneumoperitoneum	Severe pulmonary disease with hypercapnia
Septic shock	Previous surgery with significant adhesion
Severe cardiopulmonary dysfunction	Abdominal mass, peritoneal tuberculosis or obesity
Severe head trauma	Obvious evisceration

Hemodynamic instability is formal contraindication for laparoscopy. Among other absolute contraindications, one finds (Table 2):

- Hypovolemic shock stage II (non-responsive to fluid resuscitation), III and IV;

- Septic shock;

- Severe cardiopulmonary dysfunction;

- Severe head trauma;

- Impossibility of performing pneumoperitoneum.

Most contraindications are relative and exclusively determined based on surgeon's assessment and experience. Among them, one finds[9]:

- Diffuse peritonitis;

- Severe chronic obstructive pulmonary disease with hypercapnia;

- Obvious evisceration;

- Significant intra-abdominal adhesions;
- Previous abdominal surgery;
- Abdominal mass;
- Cardiorespiratory disease;
- Peritoneal tuberculosis;
- Insufficient pneumoperitoneum;
- Obesity;
- Umbilical hernia;
- Diaphragmatic hernia.

Laparoscopic Technique

This technique is applied to patients who must always be in supine position, under general anesthesia, with legs kept together and straight. They must be secured with the aid of belts; however, the health professional applying this technique must be able to change patients' position in all directions to enable adequate laparoscopic exposure of peritoneal organs. According to Koto et al (2018) the laparoscopic approach must be systematic and done by experienced surgeons[1].

- First access must be performed with the aid of 10/12mm trocar (Veress needle is not recommended);

-Pneumoperitoneum should be slowly and progressively established (target of 12-14mmHg); insufflation should be discontinued in case of increased respiratory pressure, hypotension or tachycardia;

- 0° and 30° optics can be used, but the 30° one is the best;

- If the cavity initial inventory does not recommend convert to laparotomy, other 2 trocars (5 or 12mm) should be inserted in it, preferably without blade and under direct vision, and positioned by taking into consideration the suspected site;

- Patients subjected to supramesocolic region assessment should be placed in reverse Trendelenburg position to enable examining their liver, gallbladder, spleen, diaphragm, pancreas, stomach and duodenum. Subsequently, the transverse and descending colon, and their mesocolon, should be examined. Finally, patients' position should be changed to Trendelenburg to enable assessing their rectum, Douglas pouch and pelvic organs, which must be followed by cecum and right colon assessment;

- After cranially moving the omentum, the small intestine should be fully examined with the aid of two atraumatic intestinal clamps, from the ileocecal valve to the Treitz angle;

- Patients' bladder must be fully examined;

- Methylene blue can be applied through trans nasal access, via Nasogastric Tube (NGT) or intravenous route[7].

The assessment should be systematized, the following steps must be taken to avoid leaving injuries unnoticed, it must be done carefully remembering to evaluate both sides of the small bowel (figure 1):

1. Diaphragm: it is the first region to be examined after the bleeding is controlled, since its communication with the pleural cavity may cause patient instability.
2. Liver and gallbladder;
3. Spleen;
4. Anterior wall of the stomach;
5. Gastrocolic ligament division;
6. Posterior wall of the stomach. It must be lifted with the aid of tweezers to enable assessing underneath it;
7. Pancreas and its associated retroperitoneal area;
8. Duodenum above the mesocolon;
9. Duodenum below the mesocolon;
10. Small intestine - careful inspection of the small intestine is mandatory; if peritoneum violation is confirmed or if pathological contents are identified in the abdominal cavity, it is strongly recommended to reexamine the small intestine twice, from the Treitz angle to the ileocecal junction. Approximately 10 cm of bowel must be spread between two atraumatic forceps and, subsequently, they must be rotated to enable full examination. This maneuver should be repeated until the entire bowel is examined. Clots and fibrinous exudate must be carefully removed through suction and the area must be dried to enable examining the underlying bowel. In case of signs of contusion or suspicious site are identified, blunt atraumatic forceps should be used to assess the bowel wall and to make sure about the absence of partially occluded intestinal injury. Hematomas around the bowel wall should be carefully inspected by using bowel mobilization and dry gauze to carefully remove them and to enable proper bowel wall examination;
11. Right colon (cecum, ascending colon and hepatic flexure), right kidney, hilum and ureter. The colon must be mobilized and the retroperitoneal contents must be examined;
12. Transverse colon;
13. Left colon (splenic flexure, descending and sigmoid colon), left kidney, hilum and ureter;
14. Pelvic cavity (rectum and urinary bladder);

15. Additional areas of interest and other areas that require extra attention (e.g., inferior vena cava, aorta) [1].

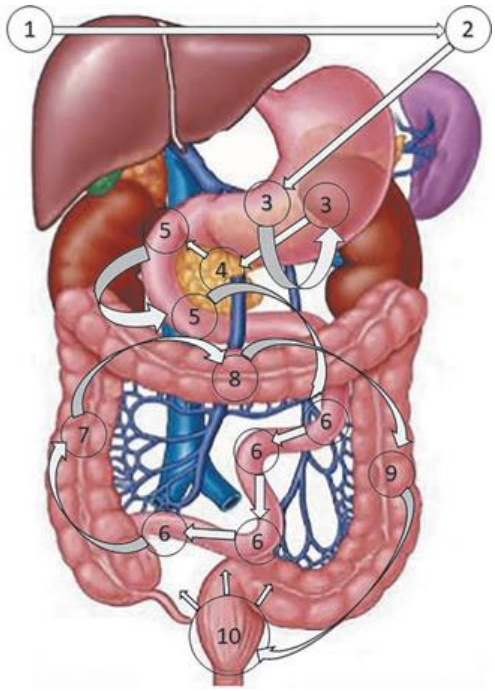

Figure 1. Systematization proposed by Koto et al (2018)[1] to investigate all the abdominal cavity in a safe way:
1-Right diaphragm and liver; **2-** left diaphragm and spleen; **3-** stomach front and back; **4-** pancreas (behind); **5-** duodenum above and below; **6-** small bowel from the Treitz to the cecal valve forward and backwards; **7-** right colon and behind; 8 - transverse colon and behind; **9-** left colon and behind and **10-** rectum and pelvis. Once the first evaluation is done it is recommended to perform a second one following the same steps.

Discussion

Laparoscopy application in stable patients with abdominal trauma has been gaining more and more room since its accuracy is close to 100% and because it is a safe approach, as long as the health institution where it is performed in has a high-performance surgical team with advanced laparoscopic skills and appropriate materials[6,8]. Quality laparoscopic equipment, well-coordinated trauma team with experience in laparoscopic surgery, and strict compliance with steps previously determined for the procedure play essential role in assuring successful laparoscopic procedures.

Assumingly, centers that meet the requirements described above should approach all stable patients through laparoscopy. Systolic blood pressure levels are the criterion most often used to define stable trauma patients, although the numbers significantly differ. SBP values lower than 90, 100 and 110 mmHg were used to indicate hemodynamic instability[8]. On the other hand, our health service considers blood pressure equal to 90 mmHg as minimum hemodynamic parameter to perform imaging or laparoscopic exams.

More recently some busy trauma centers with extensive volume of penetrating injuries are expanding the use of laparoscopy not only for diagnostic but also for therapeutic use[10]. Cabrera et al[11] used the laparoscopic approach to all the hemodynamically stable and evaluated twenty-four patients who were hemodynamically stable and underwent initial laparoscopic evaluation with diagnosis and fully therapeutic laparoscopic definitive treatment. The patients included in the study and sustained right anterior abdominal stab wound, were taken to a preoperative local exploration of the wound. The anterior, lateral and left thoracoabdominal stab wounds were not locally explored and were taken to diagnostic laparoscopy (DL). In their series Twenty-one patients required fully therapeutic laparoscopy, which included procedures as intracorporeal primary repair of hollow viscera injuries. Only one patient required conversion to open surgery due to active uncontrolled bleeding in the transverse colon mesentery and the impossibility of ruling out a lesion in the antimesenteric wall of the transverse colon[11].

Menegozzo at al[9] also corroborate these findings after analyzing a series of 31 cases of stab wounds to the abdomen where diaphragmatic lesions were present in 18 patients (58%) with no missing injuries or conversions and with a very limited performance from radiological preoperative exams, Radiography and computerized tomography yielded an accuracy of 52% and 75%, respectively, demonstrating the importance of the inclusion of laparoscopy as part of the trauma team arsenal.

Laparoscopy recommendations for trauma cases and its conversion into laparotomy significantly differ among health centers. Organ evisceration, multiple intestinal injuries, or even any injury that requires therapeutic procedures have been reported in some centers as indications for laparoscopy conversion into laparotomy; however, these injuries are successfully treated through laparoscopy in other services. Overall, continuous intra-abdominal bleeding that cannot be quickly controlled is the most common reason for conversion; it is followed by multiple highly complex lesions, hemodynamic instability, and intraoperative visualization issues. However, most patients present more than one reason for laparoscopy conversion into laparotomy. Intra-abdominal bleeding is often

associated with multiple complex injuries and with hemodynamic instability[13,14].

Retroperitoneal injuries are a potentially dangerous site for laparoscopic surgery; thus, several surgeons make the option for adopting laparotomy in these cases. According to Matsevych et al.[13], retroperitoneal lesions in stable patients were approached through laparoscopy, whereas continuous bleeding that could not be readily controlled was the main reason for laparoscopy conversion into laparotomy.

Hemodynamic (HR and SBP) and metabolic (pH, lactate, BE) instability parameters have been correlated to increased trauma patient mortality rates[4]. Increased PaCO2 during pneumoperitoneum resulted in decreased pH, although it went back to normal levels right after deflation. On the other hand, pH decrease after laparotomy was affected by metabolic factors, which persisted for one hour after surgery. It appears that laparotomy causes more metabolic disorders in trauma patients than laparoscopy. SBP, HR, pH, lactate and BE were investigated as possible predictors of complications or of conversion into trauma laparoscopy. Although pH was the only parameter presenting statistical significance, differences in values were so small, they could not be used in practice[12].

Although limited, data comparing laparoscopy to laparotomy in trauma patients have shown statistically significant reduction in the number of operative complications, perioperative mortality rates, earlier recovery of bowel function, lesser postoperative pain, shorter hospitalization time and lower infection rate in the laparoscopy group[12,13,15].

The conversion of a diagnostic laparoscopy to an open procedure caries out a significant increase in the length of stay of the patients as demonstrated by Koganti et al in 2021 (2,2 vs 4,5 days, $p<0.05$). In more than half of the patients, 178/316 (56%), the laparoscopic procedures were negative for injury requiring intervention, which was 58% of blunt cases and 55% of penetrating cases[16].

Recently Menegozzo et al published their experience with 165 laparoscopies in trauma patients and a 9,7% of conversion rate. Overall, the authors reported only 1,2% of missing injuries. According to their results a significant difference regarding hospital ($p < 0.001$) and ICU length of stay ($p = 0.006$) according to the mechanism of injury. Stab wound patients required less admission days when compared with blunt trauma patients, who spent a median of 8 days in the hospital, and 5 days in the ICU. The incidence of postoperative complications was not associated with mechanism of injury[17].

Complications inherent to surgical procedures in trauma patients may be associated with both the laparoscopic and laparotomy approaches; however, Di Saverio et al. have shown lower rate of adhesions, incisional hernias and surgical site infections. In addition, the best esthetic outcome should be taken into account since younger patients show higher trauma rates. Faster recovery leads to lower costs; besides, cases such as one single affected organ and negative laparoscopies can help reducing hospitalization time. On the other hand, these benefits must be balanced against 16%-19% false-negative laparoscopies in trauma cases[5].

The most feared complication associated with laparoscopy application in trauma patients lies on unnoticed injuries during operative exploration. Meta-analysis conducted by Uranues et al. [4] did not find significant difference in the number of unnoticed injuries, although there was significant reduction in surgical wound infection and postoperative pneumonia in the group subjected to the minimally invasive procedure. Reduced number of non-therapeutic laparotomies is another benefit of the laparoscopic therapy[5] (Table 3).

Perioperative complications associated with laparoscopy can result from the technique used to access the abdominal cavity, or they can be secondary to pneumoperitoneum, due to increased intra-abdominal pressure caused by carbon monoxide insufflation[8]. (Table 3)

Table 3. Complications associated with the laparoscopic technique

Complications associated with the laparoscopic technique	
Pneumoperitoneum-related complications	Puncture-related complications
Cardiac arrhythmias and cardiac arrest	Adjacent organ damage
Significant change in pulse and hypotension	Bleeding in solid organs (liver and spleen)
Gas embolism	Puncture, perforation of hollow viscera (stomach, small intestine and colon)
Barotrauma/Pneumothorax	Uterine perforation
Pre-peritoneal fat dissection	Bladder perforation

Postoperative complications deriving from laparoscopic procedures applied to trauma patients after 10-year review performed by Nicolau et al[18], comprised wall abscess after intestinal and gallbladder perforation. On the other hand, laparoscopic procedures converted into laparotomy procedures presented complications such as surgical site infection and one death due to multiple organ failure. In addition, reduction in the number of negative and non-therapeutic laparotomies can help reducing postoperative complications by 14.5% and 27%, respectively[14].

Conclusion

Given the advances in laparoscopic techniques, equipment improvement and surgeons' training, nowadays, laparoscopy in trauma patients represents a technique to be applied in hemodynamically stable patients, aiming to reducing the rates of non-therapeutic laparotomies, as well as their complications.

References

1. Koto MZ, Matsevych OY, Aldous C. Diagnostic Laparoscopy for Trauma: How Not to Miss Injuries. J Laparoendosc *Adv Surg Tech A*. 2018; May;28(5):506-513. doi: 10.1089/lap.2017.0562. Epub 2018 Jan 2. PMID: 29293406.
2. Birindelli A, Podda M, Segalini E, et al. Is the minimally invasive trauma surgeon the next (r)evolution of trauma surgery? Indications and outcomes of diagnostic and therapeutic trauma laparoscopy in a level 1 trauma centre. *Updates Surg*. 2020; Jun;72(2):503-512. doi: 10.1007/s13304-020-00739-0. Epub 2020 Mar 26. PMID: 32219731.
3. Renz BM, Feliciano DV. Unnecessary laparotomies for trauma: a prospective study of morbidity. *J Trauma*. 1995;38(3):350–356.
4. Uranues S, Popa DE, Diaconescu B, Schrittwieser R. Laparoscopy in penetrating abdominal trauma. *World J Surg*. 2015; Jun;39(6):1381-8. doi: 10.1007/s00268-014-2904-5. PMID: 25446491.
5. Di Saverio S, Birindelli A, Podda M et al. Trauma laparoscopy and the six w's: Why, where, who, when, what, and how? *J Trauma Acute Care Surg*. 2019; Feb;86(2):344-367. doi: 10.1097/TA.0000000000002130. PMID: 30489508.
6. Koto MZ, Matsevych OY, Mosai F, Patel S, Aldous C, Balabyeki M. Laparoscopy for blunt abdominal trauma: a challenging endeavor. *Scand J Surg*. 2019; Dec;108(4):273-279. doi: 10.1177/1457496918816927. Epub 2018 Dec 6. PMID: 30522416.
7. Loffer FD, Pent D. Indications, contraindications and complications of laparoscopy. *Obstet Gynecol Surv*. 1975; Jul;30(7):407-27. doi: 10.1097/00006254-197507000-00001. PMID: 124409.
8. Kindel T, Latchana N, Swaroop M, et al. Laparoscopy in trauma: an overview of complications and related topics. *Int J Crit Illn Inj Sci*. 2015; 5:196–205. doi:10.4103/2229-5151.165004.
9. Menegozzo CAM, Damous SHB, Alves PHF, Rocha MC, Collet e Silva FS, Baraviera T et al. "Pop in a scope": attempt to decrease the rate of unnecessary nontherapeutic laparotomies in hemodynamically stable patients with thoracoabdominal penetrating injuries. *Surg Endosc*. 2020; 34:261-267. https:// doi.org/ 10. 1007/ s00464- 019- 06761-7
10. Hajibandeh S, Hajibandeh S, Gumber AO, Wong CS. Laparoscopy versus laparotomy for the management of penetrating abdominal trauma: A systematic review and meta-analysis. *Int J Surg*. 2016; Oct;34:127-136. doi: 10.1016/j.ijsu.2016.08.524. Epub 2016 Aug 26. PMID: 27575832.
11. Cabrera Vargas LF, Pedraza M, Rincon FA, et al. Fully therapeutic laparoscopy for penetrating abdominal trauma in stable patients. *Am J Surg*. 2022; Jan;223(1):206-207. doi: 10.1016/j.amjsurg.2021.07.008. Epub 2021 Jul 17. PMID: 34294385.
12. Clarke DL, Brysiewicz P, Sartorius B, Bruce JL, Laing GL. Hypotension of B110 mmHg is associated with increased mortality in South African patients after trauma. *Scand J Surg*. 2017; 106(3):261-268. doi:10.1177/1457496916680129.
13. Matsevych O, Koto M, Balabyeki M, Aldous C. Trauma laparoscopy: when to start and when to convert? *Surg Endosc*. 2018; Mar;32(3):1344-1352. doi: 10.1007/s00464-017-5812-6. Epub 2017 Aug 10. PMID: 28799045.
14. Matsevych OY, Koto MZ, Motilall SR, Kumar N. The role of laparoscopy in management of stable patients with penetrating abdominal

trauma and organ evisceration. *J Trauma Acute Care Surg*. 2016; Aug;81(2):307-11. doi: 10.1097/TA.0000000000001064. PMID: 27032004.

15. Li Y, Xiang Y, Wu N, et al. A comparison of laparoscopy and laparotomy for the management of abdominal trauma: a systematic review and metaanalysis. *World J Surg* 2016; 39:2862–2871. doi:10.1007/s00268-015- 3212-4.
16. Koganti D, Hazen BJ, Dente CJ, Nguyen J, Gelbard RB. The role of diagnostic laparoscopy for trauma at a high-volume level one center. *Surg Endosc*. 2021; Jun;35(6):2667-2670. doi: 10.1007/s00464-020-07687-1.
17. Menegozzo CAM, Damous SHB, Sabioni GR, et al. Could trauma laparoscopy be the standard of care for hemodynamically stable patients? A retrospective analysis of 165 cases. *Surg Endosc*. 2023; May 22. doi: 10.1007/s00464-023-10121-x. Epub ahead of print. PMID: 37217684.
18. Nicolau AE, Craciun M, Vasile R, Kitkani A, Beuran M. The Role of Laparoscopy in Abdominal Trauma: A 10-Year Review. *Chirurgia (Bucur)*. 2019; May-Jun;114(3):359-368. doi: 10.21614/chirurgia.114.3.359. PMID: 31264574.