The role of bed-side laparoscopy in the management of acute mesenteric ischemia of recent onset in post-cardiac surgery patients

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ORIGINAL ARTICLE

The role of bed-side laparoscopy in the management of acute mesenteric ischemia of recent onset in post-cardiac surgery patients admitted to ICU

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Abstract

Purpose Acute mesenteric ischemia with non-occlusive mechanism (NOMI) is a possible complication after cardiac surgery in patients admitted to Intensive Care Unit (ICU). Since the diagnosis is often difficult with CT-scan, some authors have evaluated the role of bed-side diagnostic laparoscopy (DL). We aimed to contribute to this topic with a personal series.
Methods We retrospectively evaluated patients admitted to ICU after cardiac surgery since 2009 up to 2019, successively operated on for a suspected NOMI of recent onset with non-conclusive CT. They were divided into laparoscopic (Ls) and laparotomic (Lt) group, depending on whether or not they had a DL. They were compared for the CT false-positive (FP) and true-positive (TP) rate and the surgical outcome.
Results Seventy-three patients were enrolled. Lt included 30 patients (41%), Ls 43 (59%). The overall FP were 38 (52%), with a higher incidence in Ls. There was no difference in the mortality rate. The morbidity rate was higher in Lt, and especially in Lt-FP. The TP were 35 (47.9%). The mean operating time (OT) in the Lt-TP group was similar to the sum of the mean OT of the laparotomies plus that of the laparoscopies in the Ls-TP group. Conversely, when considering only laparotomic procedures, the Lt-TP had higher mean OT, such as an increased blood loss
Conclusions Post-cardiosurgical patients admitted to ICU have a relatively high rate of NOMI, in which CT-scan is often initially non-conclusive. Our data and those from the literature seem to show that in such cases bed-side DL may be an advantageous and safe procedure to avoid needless laparotomy and enables a more tailored open surgery.

Keywords Bed-side laparoscopy · Acute mesenteric ischemia · Intensive care unit · NOMI

Introduction

Acute mesenteric ischemia (AMI) is a rare life-threatening disease of the small bowel with an estimated mortality rate of 60–90% [1, 2]. It may arise from an acute obstruction of either the superior mesenteric artery or vein, or from a non-occlusive mechanism (NOMI) due to hemodynamic instability [3, 4].

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AMI may frequently occur as a severe complication after major cardiac surgery, being diagnosed in about 1% of these cases. When post-cardiac surgery patients require a prolonged admission to an Intensive Care Unit (ICU), the risk of AMI with a NOMI mechanism increases. The prognosis of such patients is particularly poor with an overall mortality rate of up to 58% [5].

The surgical treatment within 24 h from the diagnosis of AMI has been identified as an independent predictive factor of survival [6]. Moreover, an early diagnosis in these patients represents an important diagnostic challenge. Indeed, they do not show any typical abdominal symptoms or signs due to sedation or poor reactivity and often they have various confounding comorbidities. In fact, there are no laboratory studies that are sufficiently accurate to identify the presence of ischemic or necrotic bowel, and even a prompt execution of a contrast media CT-scan may be non-conclusive [7, 8].

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In this situation, diagnostic laparoscopy (DL) may represent a helpful tool due to its potential advantages: the minimally invasive approach, few peri-operative complications, the possibility of performing easily and quickly as a bed-side technique and, lastly, in the most critically ill patients, the possibility of not having to take the patient to the Radiology Unit for the CT-scan [9].

Bed-side DL in the ICU has been described previously by several authors with a substantial confirmation of the above-mentioned advantages and the possibility to prevent unnecessary laparotomies [10–12]. Moreover, a negative or non-therapeutic laparotomy can be associated with a morbidity rate as high as 5–22% and in some cases higher [13].

However, some authors have criticized the routine use of DL because of its invasive characteristics, the logistic issues involved when the laparoscopic equipment has to be brought outside of the operating theater into the UTI rooms, and last but not least, the very high cost. Moreover, some relevant procedure-related complications were occasionally reported, such as perforation, pneumoperitoneum-induced bradycardia, intraperitoneal hemorrhage and post-procedure ascitic leak from the trocar site [10, 12].

Therefore, the aim of this study was to make contribution to the evaluation of the role of bed-side DL in the diagnosis and the therapeutic outcome of suspected AMI of recent onset in potentially treatable, post-cardiac surgery patients, in whom other diagnostic studies were inconclusive.

Materials and methods

The current study prospectively recorded and retrospectively evaluated data from January 2009 to December 2019 of all consecutive patients treated for a diagnosed or suspected AMI in our Emergency Department.

Inclusion criteria for analysis were: (1) patients admitted to ICU after an urgent or elective cardiac surgery during the same hospital stay, regardless of the time interval between the operation and the transfer to ICU; (2) patients operated on shortly after the onset of suspected clinical symptoms or laboratory signs of AMI (within 12 h); (3) patients with suspected but inconclusive CT angiography (CTA) findings with a NOMI mechanism.

Patients treated on the basis of a clear diagnosis of AMI with an arterial/vein occlusion mechanism based on radiological evaluation were excluded.

The suspicious symptoms or laboratory signs of early AMI were considered the following: (1) sudden onset of severe abdominal pain (for awake/responsive patients); (2) every situation of poorly pharmacologically responsive hemodynamic instability or overt shock syndrome in which any other possible etiology, especially sepsis, was ruled out; (3) lastly, any increase in laboratory indicators, such as the non-specific intestinal enzymes LDH or CPK and/or the I-lactate, associated or not with an overt metabolic acidosis, not explainable with a septic or cardiogenic shock mechanism.

CT evaluation was performed in all the patients. AMI with a NOMI mechanism was suspected in presence of two or more of the following signs: bowel wall thickening, hypoperfusion and hypoattenuation, bowel dilatation, bowel wall hemorrhage, mesenteric fat stranding, pneumatosis intestinalis, and portal venous gas.

These instrumental examinations were performed on a 16-, 64-, or 256-section MDCT scanners (Philips Healthcare, Best, the Netherlands and GE Healthcare, Waukesha, WI), with a standard CTA abdominal protocol in arterial and portal venous phases. Non-ionic iodinated contrast material (100–120 ml) with a 300 mg/ml iodine concentration (Imeron, Bracco s.p.a. Milan, Italy or Iohexol, GE Healthcare, London, UK) was injected intravenously at a rate of 3–4 ml/s. No oral contrast material was administered. All imaging studies were evaluated by the radiologist, the ICU physician, and the surgeon performing the procedure.

According to the performed treatment, patients were divided into two categories: laparoscopic group (Ls), who had a preliminary diagnostic approach with a bed-side mode, and laparotomic group (Lt) who directly underwent an explorative laparotomic surgery.

Notably, the decision to operate on the patients directly or after laparoscopy was taken only on the basis of the laparoscopic skills and the personal belief of the various surgeons about the efficiency of the bed-side laparoscopy. Sometimes it came from organization problems. None of the single preoperative clinical features or laboratory/CT-scan signs of the patients influenced this choice. The patients within the first group who proved to have a “positive” intra-abdominal condition, i.e., the presence of ischemic/necrotic mesenteric intestinal tract, were immediately transferred in the operating room and laparotomically operated on. On the other side, patients who did not show any suspected signs of AMI, even if they had metabolic acidosis or other compatible or suggestive clinical or laboratory indicators, have never undergone surgery, neither with open nor with laparoscopic bed-side technique. In these cases, a close monitoring and possibly a 24–48 h CT re-evaluation was opted, in order to assess the possible appearance of any radiologic alterations that justify an interventional strategy.

The two groups were deeply analyzed for the various personal and pathological data, focusing on the type of cardiosurgical intervention and complications that had led them to the ICU. Moreover, they were subdivided into two subgroups according to the surgical evidence: true positive (TP), when the clinico-radiological aspects suggestive for AMI were successively confirmed by surgery, therefore requiring a bowel resection, and false positive (FP), when surgery did not show any significant intestinal abnormality.

Figure 1 reports the Prisma flow-diagram of the selection process.

The main endpoints of our study were to compare either the various clinical outcome parameters (such as mortality, morbidity and complications rate) among the various groups and subgroups, and the surgical performance indicators (such as operative time, blood loss and intra-operative complications) between the two FP subgroups.

Diagnostic laparoscopy and laparotomy

All the patients who underwent bed-side laparoscopy in our study had either an endotracheal or tracheostomy tube in place and were on mechanical ventilation. An anesthesiologist was not required during the DL procedure, because these patients were already intubated with intravenous sedation. During the procedure, the patients were monitored by the ICU nurse. Sedation consisted in a propofol infusion (30–80 g/kg/min) and remifentanil infusion (0.5–1.0 g/kg/min). A muscle relaxant, cisatracurium (1–2 g/kg/min) was also required in cases where the pneumoperitoneum was difficult to achieve. Mechanical ventilation was achieved by using the Dräger Evita 2 Dura respirator (Dräger Medical Corp., Lübeck, Germany) with the FiO_2 set at 100% during the laparoscopic procedure.

The patients were prepared and draped in the usual sterile fashion as in the operating room, and the entire procedure was performed at the bed-side, without absolutely mobilizing the patients from his normal supine position. The personnel required during the procedure included the surgeon and his assistant as well as one ICU nurse for administrating medication and monitoring and recording all relevant data. All materials used in performing the DL procedure were prepacked in a single sterile bag, which cut down on the time required for this method. A mobile tower was assembled for performing the bed-side laparoscopic procedure and this was permanently stationed during our study in the operating room that is located right next to the ICU in our hospital. The mobile tower included a 14-in Sony Trinitron monitor (Tokyo, Japan), an insufflator (W.O.M. GmbH, Ludwigstadt, Germany), and a 3CCD camera with a light source (R. Wolf Medical Instruments, Knittlingen, Germany).

The pneumoperitoneum was established by the open (Hasson) technique with a usual umbilical 10-mm access. Once the pneumoperitoneum was established, other 5-mm trocars for the operating instruments, manly grasper, were placed para-umbilically on the left and in the right lower quadrants (Fig. 2).

The abdomen was insufflated with CO_2 up to 12 mm Hg initially, and this was decreased to 8–10 mm after the insertion of the first trocar. Additional trocars (5 and 10 mm) were inserted under direct vision, as needed, by the surgeon. The abdomen was examined in all four quadrants, and if any fluid was present, samples were taken for analysis. A thorough inspection of the colon as well as the intra-peritoneal structures was initially performed,

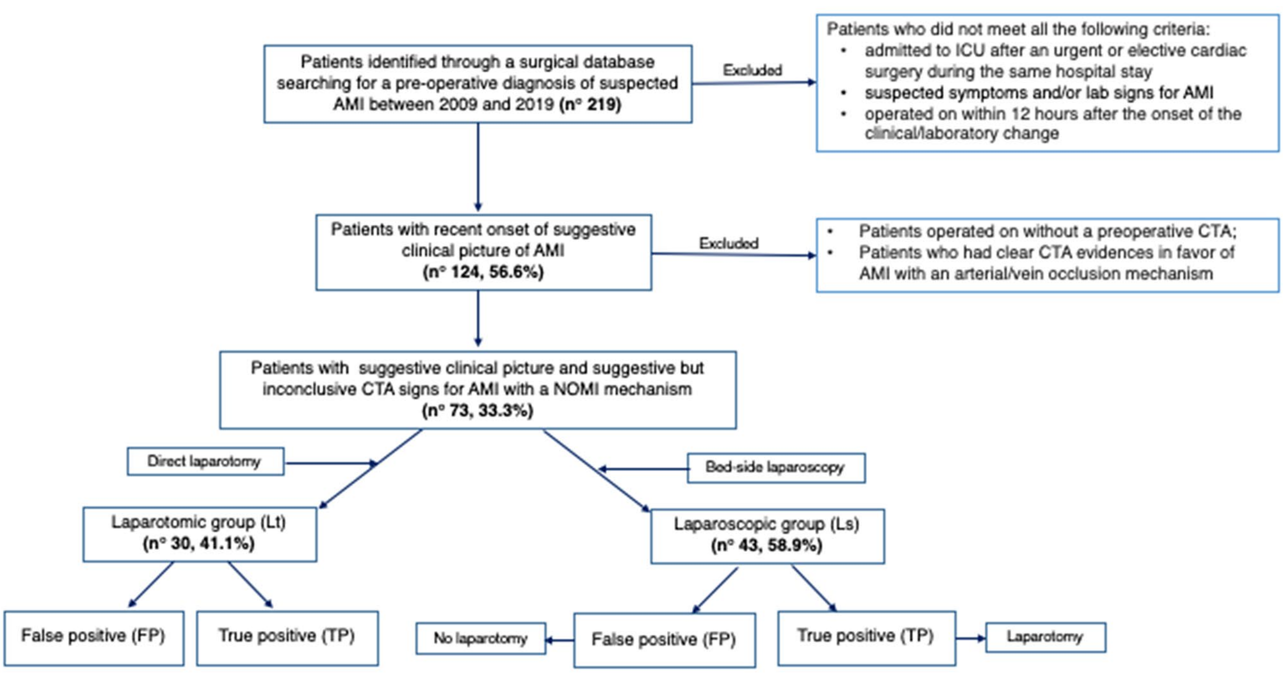

Fig. 1 Prisma diagram of the process of patients' selection. See text for abbreviations

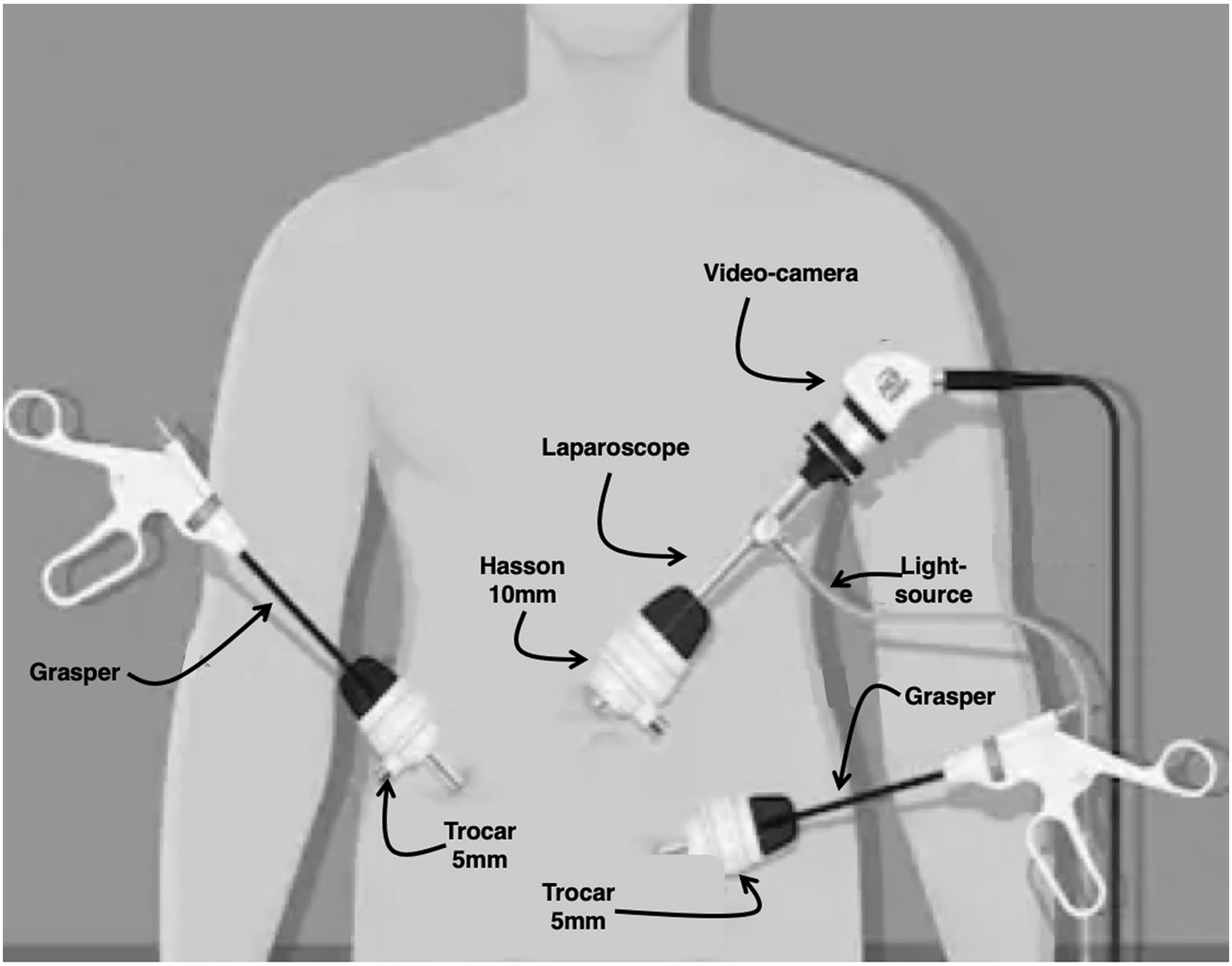

Fig. 2 Trocar positions and instrumental triangulation used for the bed-side laparoscopic procedure. For the execution of bed-side DL, the patient is left lying normally in a supine position, in order to minimize his movements. The trocars are usually three: the first of 10 mm is a Hasson which is positioned with an open technique in the umbilical position; the other two of 5 mm each, are inserted in a para-umbilical position on both sides, in a way that allows the best triangulation of the instruments. These positions change slightly depending on the side where the surgeons are positioned, which can be indifferent to the right or left of the patient, according to the disposition of the ICU instruments

followed by the running of the entire small bowel up to the ligament of Treitz. To avoid cardiocirculatory depression, intra-abdominal pressure during establishment and maintenance of the pneumoperitoneum was $\leq$ 10 mmHg. The lesser sac was not routinely explored during laparoscopic inspection.

Explorative laparotomy was performed by standard midline laparotomy of the upper and lower abdomen as always.

For each statistical analysis throughout the paper, we applied the Student's T test and the Chi-square test using the software ®Medcalc, released by the MedCalc Software Company. In particular, we have downloaded the trial version 18.5, updated in May the 17th, 2018.

Results

During the study period, 219 patients admitted to ICU after cardiac surgery were treated for AMI. Suggestive symptoms and lab signs of a recent onset of mesenteric ischemia and probable, but not conclusive, evidences of CTA scan according to a NOMI mechanism, were found in 73 patients (33%), and included in the present analysis. The Lt group included 30 patients (41%), whereas the other one (Ls) contained 43 patients (59%). Concerning the CT-scan suspicious signs of ischemia, even if the analysis of which is not the specific objective of this study, we just report that 2 patients had a bowel wall hemorrhage, 33 an association between bowel wall thickening + mesenteric fat stranding, 21 a picture of bowel hypoperfusion and hypoattenuation, 12 bowel wall thickening + bowel dilatation, 3 a pneumatosis intestinalis and lastly 2 a pneumatosis intestinalis together with the evidence of portal venous gas. There was no difference in the distribution rate of these signs in the various considered groups and subgroups.

Table 1 shows the personal and pathological features of the patients included in the series. Special attention should be given to the types of cardiac surgery before admission to ICU, and the clinical and radiological pictures suspected for AMI. As evident, there was a good uniformity in the two groups for each data examined, except for cardiogenic shock, which was more frequently found in the Lt group and vice versa for the cardiogenic stroke.

Table 2 reports the clinical outcome data within the various groups and subgroups. It is of note that the FP patients (38, 52.0%) were significantly more numerous in the Ls group. However, when dividing the whole study period in two halves, we had the following results, as shown in Table 2: an increase in the absolute number of DL and in the DL/Lt rate (even if not significant); a sharp increase (although still not significant) of the FP rate, from nearly 53% to over 80%; finally, the appearance of a statistically significant difference in the percentage of FP between the Ls group and the Lt group, a difference that was not present in the first half of the time.

Table 1 Personal and pathological features of the patients included in the two groups

Feature	Lt group (30)	Ls group (43)	*p*
Anagraphic			
F/M	14/16	20/23	ns
Mean age	77 ± 13	80 ± 18	ns
Mean BMI	29 ± 4	30 ± 7	ns
Mean ASA	3.88 ± 0.8	3.82 ± 0.6	ns
Types of cardiac surgery			
Urgency/elective U/E	5/25	7/36	ns
Aortic valvuloplasty substitution U/E (%)	0/5 (16.6)	1/3 (9.3)	ns
Mitral valvuloplasty substitution U/E (%)	1/6 (23.3)	0/9 (20.9)	ns
Multiple valves surgery U/E (%)	0/3 (10)	0/6 (13.9)	ns
Inter-atrial defect closure U/E (%)	1/1 (6.6)	1/3 (9.3)	ns
Inter-ventricular defect closure U/E (%)	0/1 (3.3)	0/3 (6.9)	ns
CABG U/E (%)	2/9 (36.6)	1/12 (30.2)	ns
Ascendant aorta substitution (dissection) U (%)	1 (3.3)	2 (4.6)	ns
Cardiac tamponade repair (%)	0	2 (4.6)	ns
Complications that determined the ICU admission			
Cardiogenic shock (%)	16 (53.3)	10 (23.2)	**0.008**
MOF (%)	1 (3.3)	6 (13.9)	ns
Cardiogenic stroke (%)	4 (13.3)	15 (34.8)	**0.03**
Cardiac-respiratory arrest (%)	9 (30)	12 (27.9)	ns
Clinical/lab suspicious signs of AMI			
Sudden onset of severe abdominal pain (awaken patients) (%)	7 (23.3)	11 (25.5)	ns
Hematochezia (%)	4 (13.3)	6 (13.9)	ns
Poorly pharmacologically responsive hemodynamic instability where other possible etiologies (especially sepsis) have been excluded (%)	9 (30)	12 (27.9)	ns
Increase in laboratory parameters such as the non-specific intestinal enzymes LDH or CPK and/or the I-lactate, associated or not with an overt metabolic acidosis (%)	10 (33.3)	14 (32.5)	ns
CPK (U/l)	333 ± 81	308 ± 99	ns
LDH (U/l)	291 ± 102	277 ± 88	ns
pH	7.28 ± 0.07	7.26 ± 0.06	ns
[Base excess]	3 ± 1.9	4 ± 2.4	ns
I-lactate (mEq/l)	6 ± 3.3	5 ± 3.9	ns

Bold indicates the significant *p* value results

Table 2 Surgical mortality and morbidity rate in the whole series, in the Lt/Ls groups and FP/TP subgroups

Parameters	Whole series	Lt group FP/TP	Ls group FP/TP	*p** *p*°/*p*^
Number of patients (%)	73	30 (41.0) 8 (26.7)/22 (73.3)	43 (58.9) 30 (69.7)/13(30.2)	– **0.03/0.03**
Number of patients in the first half of time (%)	33	16 (48.4) 5 (31.5)/11 (68.7)	17 (51.6) 9 (52.9)/8 (47.1)	– ns/ns
Number of patients in the second half of time (%)	40	14 (35) 3 (21.4)/11 (78.6)	26 (65) 21 (80.7)/5 (19.3)	– **0.04/0.04**
Mortality (%)	15 (20.5) (42.5 out of TP)	9 (30.0) 1 (3.3)/8 (26.6)	6 (13.9) 0 (0)/6 (13.9)	ns ns/ns
Morbidity (%)	21 (28.7)	14 (46.6) 7 (23.3)/7 (23.3)	7 (16.2) 1 (2.3)/6 (13.9)	**0.03** **0.01/**ns
Wound infection (%)	10 (13.6)	8 (26.6) 5 (16.6)/3 (10.0)	2 (4.6) 1 (2.3)/1 (2.3)	**0.02** **0.04/**ns
Incisional hernia (%)	4 (5.4)	4 (13.3) 3 (10)/1 (3.3)	0 0/0	ns ns/ns
Anastomotic leakage (%)	4 (5.4)	3 (10) 0/3 (10)	1 (2.3) 0/1 (2.3)	ns ns/ns
Paralytic ileus (%) (more than 7 days)	3 (4.1)	1 (3.3) 1 (3.3)/0 (0)	2 (4.6) 1 (2.3)/1 (2.3)	ns ns/ns

Bold indicates the significant *p* value results

ns statistically non-significant

*Lt vs Ls groups

°Lt-FP vs Ls-FP subgroups

^Lt-TP vs Ls-FP subgroups

Conversely, there was no difference in the mortality rate between Lt and Ls, but the morbidity rate was higher in the Lt compared to Ls groups, and concerning the subgroups, in the Lt-FP compared to Ls-FP only. In particular, out of the various post-operative complication, the wound infections had the highest incidence and it was higher in the Lt vs Ls group and in the Lt-FP vs Ls-FP subgroups.

Regarding the TP patients (35, 47.9%), the pathophysiology of their mesenteric ischemia was considered purely non-occlusive in 30 cases (85.7%), whereas 5 cases (14.2%) had a concomitant diffuse splanchnic arteriopathy, which probably contributed to the onset of the clinical picture. In particular, in Fig. 3 we report the distribution of the various intra-operative findings in this category. It shows that a longer than 1-m ischemic/necrotic segment was the most frequent picture, and it was more often encountered in the Lt-TP vs Ls-TP population; whereas, an opposite distribution occurred for the finding of a less than/equal to 1 m.

Focusing on the comparison between Ls-TP and Lt-TP subgroups, the mean operating time (OT) in the Lt-TP group was similar to the sum of the mean OT of the laparotomies plus that of the laparoscopies in the Ls-TP group. Conversely, when considering only laparotomic procedures, the Lt-TP had higher mean OT, such as an increased blood loss. Conversely, no differences were evidenced either in the overall intra-operative complications rate or in the single ones (Table 3).

Discussion

Acute abdominal problems are common in critically ill patients. Although they may have an initial condition requiring admission to the ICU, they are most likely to have a complicated course of the underlying disease, regardless of its etiology and pathophysiological mechanism. Unfortunately, the abdominal signs and symptoms in such patients are often masked and difficult to assess, due both to the concomitant presence of major confounding disorders and the necessity of sedation and mechanical ventilation [14]. Thus, in case of suspected abdominal emergencies, it may be very challenging to make a prompt and correct diagnosis [15].

Patients admitted to ICU after cardiac surgery have a relatively high rate of abdominal emergencies due to AMI compared to the normal population. It occurs between 1 and 10%, and varies according to study design, definition of disease and selection of the patient population [5].

A frequent mechanism of AMI after cardiac surgery is NOMI, due to a low cardiac output and flow state in the splanchnic area, whereas mesenteric vessels are permeable [16]. In a minor percentage, a combination between NOMI

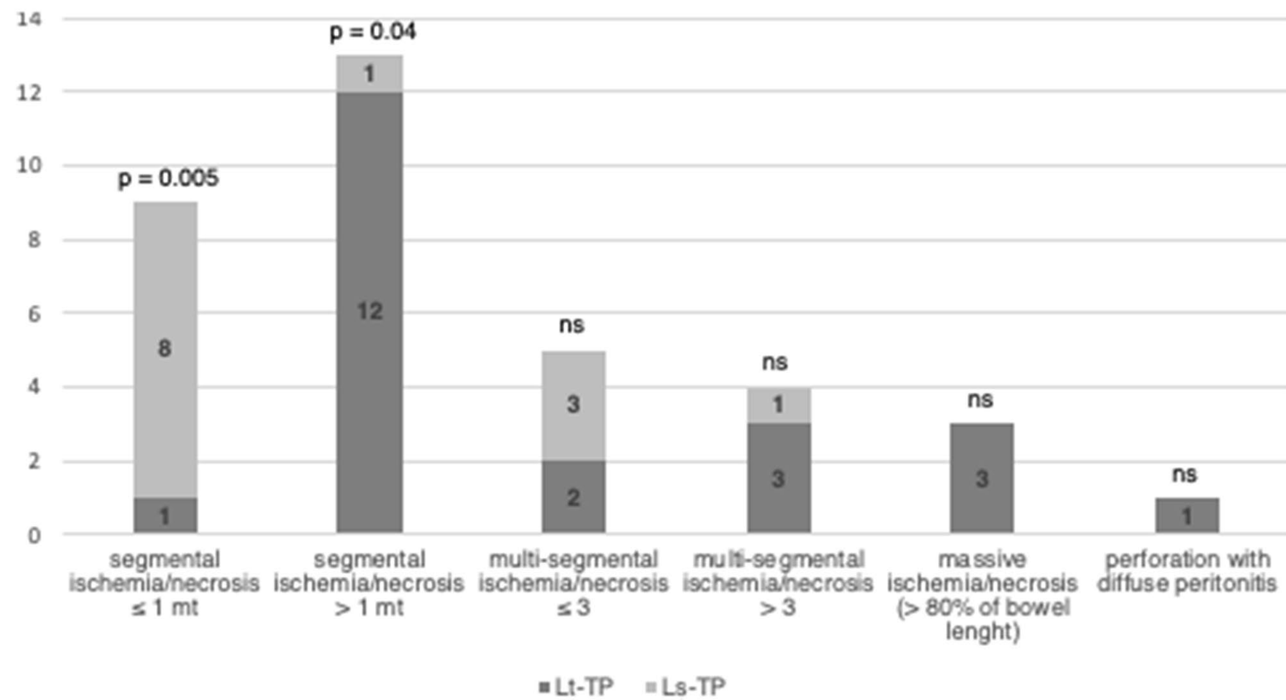

Fig. 3 Distribution of the intestinal pathological findings in the Lt subgroups

Table 3 Surgical outcome in the two TP subgroups

	Lt-TP	Ls-TP	*p*
Operative time (min)	138 ± 39	149 ± 17	ns
		98 ± 31 (excluding laparoscopic time)	**0.003**
Blood loss (ml)	315 ± 38	280 ± 52	**0.028**
Intra-operative complications (%)	7 (31.8)	1 (7.6)	ns
Small bowel perforation (%)	4(18.1)	1 (7.6)	ns
Colonic electric injury (%)	2(9.0)	0 (0)	ns
Spleen injury due to adherences (%)	1(4.5)	0 (0)	ns

Bold indicates the significant *p* value results

ns statistically non-significant

and non-obliterative arterial thrombosis may be seen. In our study, we have evaluated patients with both conditions since they share the same diagnostic and therapeutic difficulties.

Concerning the diagnosis, such a dramatic disorder may be suspected when a patient's condition does not improve during the post+operative course, or, more typically, when an otherwise unexplained and rapid worsening is observed. Up to now the CTA represents the gold standard in the diagnosis of AMI of an occlusive origin [7, 8, 17].

Unfortunately, when the NOMI is prevalent, the sensitivity and specificity of this instrumental examination decreases, especially at onset or at an early stage of the disease, which is however the most reversible phase. Indeed, in these conditions the CTA usually shows a normal bowel wall and a high variability of its contrast enhancement ranging from absent or diminished to increased [18, 19]. Thus, the false-positive and false-negative results need to be considered in this study population.

Due to this diagnostic controversy and the fact that patients with a recent onset of AMI with a NOMI have a better prognosis, we have focused our attention on them. In particular, we considered the patients who were operated on, despite the suggestive but not conclusive CTA findings, but considering the potentially rapid life-threatening course of this disease. In some of those cases, surgeons decided to perform a bed-side laparoscopy to achieve a diagnostic confirmation, depending on their skills and personal opinion, since this technique is yet to be validated and standardized. Thus, we were able to retrospectively evidence both the rate of CTA FP and TP patients and how bed-side laparoscopy affected their course compared to direct laparotomy.

The use of bed-side laparoscopy after abdominal surgery of the aorta to diagnose gangrenous bowel was fist described in 1989 by Iberti et al. [20]. In the last 30 years, the improved technology of laparoscopy has offered an attractive and accurate diagnostic bed-side modality for critically ill patients who are admitted at the ICU and need a timely abdominal evaluation. Several authors have described their experience with this procedure [16, 21–23]. However, to date bed-side laparoscopy is yet to become a widespread diagnostic tool. Therefore, our results may provide a major contribution to this issue.

With regard to FP patients, we found that nearly half of the cases did not show, intra-operatively, any significant sign of bowel ischemia. Such results of an extremely high rate of FP are perfectly aligned with the literature. Indeed, in a case series by Karakasalides et al. 20/35 (57.1%), patients showed a negative laparoscopy (even if some of them had had an abdominal US only) [24]. Furthermore, a recent study by Sajid MA et al. found 50% of negative laparoscopic explorations, but none of them had undergone a previous CT-scan [25]. Other authors have reported similar results, with or without a previous CT [9, 26, 27]. Lastly, in an original study by Cocorulo et al. on ICU patients with clinically suspected AMI who met the CTA exclusion-criteria of an occlusive origin, the authors applied a two-look bed-side laparoscopic procedure protocol, showing at the first assessment up to 70% of the FP rate, which decreased to 50% in the second assessment, performed after 48 h [16]. Furthermore, our study shows that all patients undergoing a direct laparotomic exploration, and especially the FP group, have a significantly higher morbidity rate, mainly due to surgical site infection, than those who had a previous bed-side laparoscopic evaluation. Hence, all of these results may indicate the usefulness of bed-side laparoscopy in case of clinical/CT-scan suspected of AMI in order to avoid needless laparotomy, which could however carry harmful consequences for the patient. A somewhat unexpected result of our study has been the higher rate of FP patients in the Ls compared to the Lt group (30.2% vs 69.7%), even if a similar data is reported by other authors (23). Moreover, the comparison of the FP/Lt rate observed in the first and the second period, revealed a relevant increased in the latter, when it became significantly higher than the FP/Lt rate. Such a progressive worsening of this parameter is certainly the worst result of our study. To explain this phenomenon, we can bring the following reasons: (1) the growing experience in emergency laparoscopy could have augmented the surgeons propensity towards the DL, even in the most doubtful cases, feeling the confidence to reach promising results, without a relevant morbidity rate; (2) the rapid increase of our series, due to the fruitful collaboration with the ICU, may have increased the conviction that the alternative choices to DL, consisting of either an immediate open surgery or, conversely, an initially non-operative management, can both expose the patients to even more life-threatening complications; finally, (3) the fact that about four years ago important organizational changes have occurred in our hospital, making it possible to have a laparoscopic tower in ICU more quickly and efficiently, thus reducing again the operative time and risk of complications. Despite these possible explanations, we still believe that this result might reflect a too liberal use of the DL by the surgeons of our Division. Thus, we feel to advise emergency surgeons, even if they believe like us in the effectiveness of DL, to maintain a greater balance by restricting the indications to DL to those cases in which the suspicion of AMI is more consistent and threatening, especially in those hospital with low patients flow or limited organization resources.

Finally, with regard to the TP patients, we wish to highlight the most originals stemming from our study, i.e., the significant decrease in the laparotomic time (but not in intra-operative complication rate) and, to a lesser extent, in the blood loss in patients who had a previous laparoscopic exploration, compared to those with a direct laparotomy. In our opinion this data could depend upon the fact that a previous bed-side laparoscopy enables the surgeon to avoid diagnostic maneuvers of exploration during the subsequent laparotomy and to perform a more tailored operation, possibly even with a smaller incision. Moreover, we believe that, in extreme cases of patients who have a very high suspicion of AMI and equally high contraindications to be moved into the Radiology Units for reasons related to their clinical conditions or for logistical problems of the hospital, a direct execution of the DL, even without a previous CT-scan, may be hypothesized, in order to save time. However, we are aware that such an interpretation, which is decisively in favor of bed-side laparoscopy, may be strongly influenced in our study by the bias of a heterogenic series as regards the pathological findings, and the arbitrative choice of the various surgeons without a randomization method. Further studies with more homogeneous patients are therefore necessary to confirm our opinion that bed-side laparoscopy not only allows to rule out the FP patients, but also facilitate a further laparotomic operation in the TP ones.

The role of other potential laboratory indicators (lactate value, white blood count, enzymes of intestinal necrosis, etc.) and CTA findings should be further evaluated too.

In conclusion, our data seem to confirm that bed-side diagnostic laparoscopy when applied to patients with suspected AMI after a major cardio-surgical operation, is an advantageous and safe procedure to avoid needless laparotomy when the disease is not present and enables a more tailored open surgery when it is confirmed.

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Author contributions CB: he devised the study design and methodology and wrote the entire text; GA: he gave his contribution in the literature evaluation and comparison; AG: he was the principal contributor in the data processing; DP: she gave her contribution in the revision of collected and processed data; GF: he was involved in collecting data; AMDB and VI: they have cured the database for data collection and maintained contacts with the ICU to find useful information for the study; PP: he developed the bed-side laparoscopy protocol; JM: he made the overall revision of the entire article, with particular reference to the methodology.

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Availability of data and material All data are present in our electronic archiving databases and fully accessible.

Compliance with ethical standards

Conflict of interest Carlo Bergamini, Giovanni Alemanno, Alessio Giordano. Desiré Pantalone, Giovanni Fontani, Anna Maria Di Bella, Veronica Iacopini, Paolo Prosperi and Jacopo Martellucci declare that they have no conflict of interest.

Ethical approval The entire research was supervised while it was being carried out by our local Ethics Committee, whose purpose is to protect the rights and welfare of human subjects during their participation in clinical studies.

Research involving human participants and/or animals All the patients belonging to the series examined were treated according to our institutional protocols outlined to ensure that treatment is as humane as possible, and, in particular, in compliance with the 1964 Helsinki declaration and its subsequent amendments. The entire research was supervised while it was being carried out by our local Ethics Committee, whose purpose is to protect the rights and welfare of human subjects during their participation in clinical studies. This article does not contain any studies on animals performed by any of the authors.

Consent to participate Not applicable since the study is retrospective.

Informed consent A written informed consent was obtained from all the patients who survived for the publication of their clinical data.

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