Diagnostic challenges in postoperative intra-abdominal sepsis in critically ill patients: when to reoperate?

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Review Article

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ABSTRACT

Objective: To review common diagnostic techniques to help surgeons find the most suitable one to diagnose postoperative intra-abdominal sepsis (IAS).

Design: The topic was searched on MEDLINE, Embase and Cochrane Library databases.

Setting: Review study.

Subjects: Different diagnostic techniques for IAS.

Intervention: Findings of selected researches were included in this study and analyzed to find the best diagnostiuc method for intra-abdominal sepsis.

Main outcome measures: IAS presents severe morbidity and mortality, and its early diagnosis can improve the outcome. Currently, there is no consensus among surgeons on a single diagnostic modality that should be used while deciding reoperation in patients with postoperative IAS.

Results: Though it has a high sensitivity for abdominal infections, computed tomography has limited applications due to mobility and time constraints. Diagnostic laparoscopy is a safe process with high capabilities and the possibility of use at the bedside. Diagnostic Peritoneal Lavage (DPL) has high sensitivity, and the patients tested positive for DPL can be subjected to exploratory laparotomy, depending on the severity. Reoperation Predictive Index (ARPI) is the only index reported as an aid for this purpose. Serial Intra-abdominal pressure has also emerged as a potential diagnostic tool.

Conclusion: A proper selection of diagnostic modality is expected to improve the outcome in IAS, which presents high mortality risk and a limited time frame.

KEYWORDS: Intra-abdominal sepsis, Diagnostic laparoscopy, Diagnostic peritoneal lavage, Abdominal Reoperation Predictive Index (ARPI), Serial Intra-abdominal pressure.

INTRODUCTION

Sepsis is a significant cause of mortality in surgical intensive care units [1, 2]. Intra-abdominal sepsis (IAS) includes localized and generalized peritonitis and is a systemic inflammatory response to infection. IAS is the second most common sepsis in Intensive Care Units (ICUs), presenting severe morbidity and mortality [3, 4]. In intra-abdominal infections (IAI), the reported mortality rate is about 10%; however, in patients with acute sepsis, it can reach 40% or higher [1]. In terms of the number of cases presented in ICUs, sepsis accounts for about 25% of all admissions. Moreover, during their stay in the hospital, a significant fraction (~12%) of patients also develop sepsis, further increasing the disease burden.

The reported incidence rates of sepsis have increased in recent years [5]. The increase has been attributed to changes in demographic and invasive medical and intensive care measures [6]. The Surviving Sepsis Campaign (SSC) guidelines are recently updated [4]. These guidelines are used to manage sepsis in general, but they are not specific to the management of IAIs. Sepsis is a systemic process; however, an organ-specific management approach for sepsis can be more effective as the pathophysiological cascade of sepsis may differ from organ to organ.

It is well established that sepsis early diagnosis plays an essential role in effective control and favorable clinical outcome[7]. Sepsis can be controlled/treated by nonoperative or operative means, depending on the

anatomical source of infection, severity, and patient-related factors [1, 8-12]. After the initial surgery, early diagnosis of IAS and an early sepsis control by relaparotomy might significantly reduce the risk of multiorgan failure and mortality[13]. The decision-making process is not straightforward. Mainly, in most of the cases presented at the Emergency Department (ED), the severity of sepsis is not apparent enough to allow easy diagnosis and management [14-16]. Considerable efforts have been made to devise an assessment criterion for sepsis. Careful consideration is nonetheless required in assessing the sensitivity and specificity of screening tools available for sepsis. For example, systemic inflammatory response syndrome (SIRS)-based criteria for sepsis have been in wide use. However, it has been found that the SIRS-based criteria have very low specificity for sepsis, though its sensitivity is good. Since the specificity is a significant consideration, in key recommendations in Sepsis [3], SIRS criteria have been eliminated, and the quick SOFA (qSOFA) score is introduced due to its higher specificity[17]. However, in the ED setting, the effectiveness of qSOFA is not fully established [18, 19].

Unavailability of sensitive, specific, and rapid methods for monitoring sepsis in the critical care settings makes the timely and adequate management of sepsis difficult [2, 9, 14, 20]. The situation is even more complicated in postoperative IAS[21]. As stated above, postoperative IAS is associated with a high mortality rate (28-47%) [3]. Early diagnosis and proper management are critical in reducing the probability of adverse outcomes. Due to restrictions in the patient's movement and high mortality risks associated with diagnostic assessments, the surgeons face a dilemma selecting cases suitable for reoperation and not [22-24]. The dilemma is compounded by the risks associated with the use of different diagnosis techniques, portability, and sensitivity and specificity [21, 25-27]. In this scenario, critical concerns for surgeons are (I) the possibility of rapidly deteriorating septic state (II) the stress and complications of the initial surgery (III) the potential risk of ischemia to the tissue and other complications during relaparotomy.

The present research aimed to review techniques commonly used to help surgeons decide the suitable management strategy for postoperative IAS. Additionally, the present research presents a brief discussion of sepsis's epidemiology and pathology, abdominal sepsis, and postoperative IAS. A detailed account discussion is made on the advantages and disadvantages of diagnostic techniques used in the surgical course's clinical decision process. Attempts have been made to elucidate the scenario with the help of seminal articles. While discussing the diagnostic techniques, the focus has been made to present significance, sensitivity, and discriminate power wherever available. Scales and scores available for sepsis and reoperation assessment in postoperative IAS are discussed in detail.

LITERATURE REVIEW

Postoperative sepsis is usually caused by a failure to eradicate infection at an initial laparotomy or anastomotic breakdown and can be extremely difficult to diagnose. Detection of complicated intra-abdominal sepsis is primarily a clinical diagnosis. However, critically ill patients may be difficult to evaluate due to distracting injuries, respiratory failure, obtundation, or other comorbidities [28]. Some researches reported the efficacy of clinical assessment of patients admitted to the emergency department with abdominal pain and a systemic inflammatory response, including fever, tachycardia, tachypnoea, and peritonitis in some cases [29]. Signs of hypoperfusion and hypotension includings oliguria, lactic acidosis, and acute alteration of mental

status are indicative of ongoing sepsis [30]. Some researches have assessed the predictive value of Creactive protein (CRP) for postoperative intra-abdominal sepsis [31-33]. Typically, CRP peaks between postoperative day (POD) 2 and POD 3 (about 12–24 h after interleukin (IL)- 6 peaks) and declines to baseline level on POD 5 [33]. Ultrasound-guided diagnostic drainage of suspicious fluid collections, combined with therapeutic tube insertion on demand, help surgeons to diagnose conditions including intra-abdominal abscesses, hematoma, and pancreatic fistula [34, 35]. Computed tomography (CT) scan is considered as the diagnostic gold standard for both secondary and ongoing peritonitis, with diagnostic sensitivity of 97.2% [36]. Laparatomy has been considered as one of the most routine diagnostic techniques for the postoperative intra-abdominal sepsis [37]. However, this technique presents the risk of the development of acute abdominal compartment syndrome (ACS), which known by peritonitis and capillary leakage and fluid resuscitation [37, 38]. Documented data reported that when CT and abdominal ultrasound are not available, diagnostic peritoneal lavage may be useful for the diagnosis of postoperative intra-abdominal sepsis [39]. In keeping with this, there is no unique standard protocol for the diagnosis of postoperative intra-abdominal sepsis in critically ill patients.

DISCUSSION AND DEFINITIONS

Sources of infection, sepsis, and septic shock

Sepsis is the systemic inflammatory response to an infection [40-42]. It can be defined as "life-threatening organ dysfunction caused by a dysregulated host response to infection". Sequential Organ Failure Assessment (SOFA) score is used to identify the organ dysfunction. Severe sepsis is the condition involving sepsis and dysfunction of at least one acute organ, hypoperfusion, or hypotension. The SIRS score, which was used in the earlier definitions of sepsis, is now removed. The quick SOFA (qSOFA) has been introduced in the new definition of sepsis (Table 1)[43]. qSOFA is a specific attempt to identify high-risk patients with a suspected infection at the bedside. A several-fold increase in in-hospital mortality has been reported with an increase in two or higher points in qSOFA, reflecting the prognostication efficacy of the score [43]. However, the efficacy of qSOFA in the ED setting is not fully established. Dykes *et al*. reported a comparative study on qSOFA and SIRS criteria for early Sepsis[17]. The study involved an elderly population, and the primary outcome was sepsis within 48 hours of admission. They reported that the qSOFA had lower sensitivity than SIRS (44.7% vs. 80.0%) but higher specificity (83.6% vs. 25.7%). Their results reflect low sensitivity of qSOFA; however, based on specificity and positive predictive value, the authors concluded that veterans with higher qSOFA had a high probability of having sepsis. The National Early Warning Score (NEWS) score has also been reported to be useful in the ED setting; Lim *et al*. recently reported the effectiveness of NEWS in infection-related acute medical settings [44]. SIRS, SOFA, qSOFA, NEWS, and other scores are useful and have their own merits; however, none of them is specific enough to assist surgeons in deciding the feasibility of reoperation in patients with post-operative IAS.

Post-operative sepsis

Prophylactic antimicrobial therapy and other advances have reduced the incidences of surgery bound infections. However, infections are still the leading causes of post-surgery morbidity and mortality[24, 45-48]. Failure to remove infection at the initial surgery or anastomotic breakdown is the major contributor to

postoperative IAS. Postoperative IAS is a challenging condition to diagnose. The outcome of patients with postoperative IAIs correlates with the delay between the first and the corrective operation. With a rapid control of infection sources, the outcome is known to improve [7, 21].

Disease dependent and critical condition-dependent scoring systems for IAI

The abdomen is the second most common source of sepsis[1, 49, 50]. Peritonitis, a common etiology of IAS, is categorized into primary, secondary, or tertiary. Around 11% of all patients with peritonitis are known to have complications of severe sepsis [51-53]. Early diagnosis and treatment of IAIs are important to sepsis control [2, 54-57]. As many cases of complicated IAI involve ICU setting, severity scoring systems for IAI can be disease-independent or disease-specific. Disease independent scores include Acute Physiology and Chronic Health Evaluation (APACHE) II and Simplified Acute Physiology Score (SAPS II). Among disease-specific scores, Mannheim Peritonitis Index (MPI) is a valuable prognostic tool. However, some concerns are raised regarding the prognostic significance of APACHE II in peritonitis, as the score does not include the role of interventions. The MPI has the advantage of being specific for peritonitis. However, these scoring systems or their combinations are not specific to prognosticate the reoperation decision-making process in postoperative IAS.

Reoperation diagnostic techniques used for sepsis assessment

After abdominal surgery, reoperation presents severe morbidity and mortality risks, especially in IAS, in critically ill patients [22, 26, 48, 58, 59]. Currently, for patients with postoperative IAS, there are no accepted guidelines or scoring systems that can be used for selecting the patients for relaparotomy for sepsis control. Even with the recent advances in diagnostic technologies (radiological or laparoscopic), prognosis after laparotomy remains a challenge. A combination of diagnostic tests and clinical examinations is used in the clinical decision-making process. Different laboratory, radiologic, and interventional diagnostic techniques can examine the abdomen in postoperative IAS (Figure 1)[58]. Several factors need to be analyzed in the critical care setting before selecting an appropriate diagnostic modality for a patient with suspected postoperative IAS. The foremost consideration is the hemodynamic stability of the patient. For unstable patients, techniques that involve the transfer of patients from the ICU to another unit might not be feasible. Computerized tomography is among the most common modalities for the intraabdominal examination for stable patients. The comparative efficacy of Computer Tomography (CT) and ultrasonography (US) for the diagnosis IAIs have been reported in several studies [60]. It may be noted that though, in the critical care setting, portability of the sonography techniques offers an advantage over CT, the considerably low sensitivity and specificity of sonography make it of little help in surgical decision on patients with postoperative IAS. Magnetic resonance imaging and nuclear techniques are not routinely available in most hospitals in the ICU. Therefore their uses are expected to have limited applications in postoperative IAS[61]. When imaging is not feasible or conclusive in identifying the causative pathology, diagnostic laparoscopy techniques or exploratory laparotomy may be used [62]. Abdominal Reoperation Predictive Index (ARPI) is the only predictive index developed for assessing the suitability of the surgical approach in postoperative IAS[23]

Serial Intra-abdominal pressure is another technique that has been explored for the prognosis of the patient with suspected postoperative IAS. A detailed discussion of these techniques is presented below.

Computed tomography (CT)

CT of the abdomen is extensively explored for IAI because of its high accuracy in diagnosing intra-abdominal abscess [63-68]. However, a few factors restrict the use of CT in the critical care setting, including the risk associated with the movement of the patient from the safety of the ICU to the radiology room and the transfer and measurement associated time delays. Significant respiratory and hemodynamic deterioration can take place during transportation. Careful consideration of the patient's condition should be given before using CT in a patient with suspected postoperative IAS. CT scan has high sensitivity and specificity for intra-abdominal fluid collections and abscesses [69-71]. Velmahos *et al*. conducted a prospective case series of 85 critically injured patients. The reported sensitivity was around 98% in their work, and the reported specificity was around 62%. Around 70% of the total patients were reported to be benefited from treatment changes due to the inputs provided from the CT scan [36]. Kumta *et al*. indicated that in around 80% of the patients in their study group, the management course was altered based on the decisions after CT [72]. As the patient's transfer to a CT scan is a severe limitation of the management of patients receiving critical care, one way to overcome this limitation is the use of portable CT [72]. However, portable CT is expensive, and not much work has been reported on its diagnostic efficacy for postoperative IAS. Maher *et al*. investigated the quality and clinical Impact of portable abdominal CT in 100 cases. [73]. They reported the relatively low quality of the image obtained from portable CT compared to the image obtained from conventional CT. However, the authors concluded that, despite the inferior image quality, portable abdominal CT provides essential diagnostic information with the benefit of avoiding transport of the patient outside the ICU. Nonetheless, the interpretation of portable CT scans should be conducted with caution. Even the suitability of conventional CT scans for the patient with suspected postoperative IAS was questioned in some studies. Norwood *et al*. analyzed the influence of CT scans on the clinical decisions made on critically ill patients. They concluded 70% of scans were either of no help or were not used in the clinical decision process [74]. CT examinations should therefore be used according to proven clinical rationale, when case severity is high, alternative diagnostic techniques may be explored[75]. There is not much data on predicting the power of CT scans for reoperation postoperative IAS. Bader *et al*. focused on elucidating early indication for relaparotomy in patients with diffuse secondary peritonitis. They reported a high sensitivity in CT-scan (97.2%) than in conventional radiography (66.2%) or in ultrasonography (44.3%)[76]. The use of multidetector-row CT (MDCT) scanners can further enhance the diagnostic efficacy for detecting the cause of abdominal sepsis. A sensitivity of 95% and a specificity of 91% was reported for abdominal sepsis[77]. Authors, however, cautioned about the radiation dose constraint associated with the process.

Bedside Diagnostic Laparoscopy (BDL)

Due to the risk associated with the transport of patients from ICU and in situations when routine radiological techniques do not yield a conclusive diagnosis, bedside diagnostic techniques are advised to identify causative intra-abdominal pathology [78-81]. Furthermore, bedside techniques do not interrupt the ongoing treatment in the ICU and can also help in the cost and time minimization. In the critical care setting, BDL is a feasible, safe, and efficient tool to examine the intraabdominal pathology of hemodynamically unstable patients[79]. BDL has high accuracy for IAS diagnosis. BDL in appropriately selected patients can, therefore,

be of great help in avoiding negative laparotomies [82]. Even in unstable patients with abdominal sepsis of unknown origin, DL has been found to have good accuracy with a high definitive diagnosis rate (86-100%)[78]. BDL can be successfully used for intubated as well as for non-intubated patients. It can be used when there are other signs of sepsis, but laparotomy indications are not clear. Diagnostic laparoscopy (DL) has very high sensitivity (98%) and specificity (96%) for unexplained severe abdominal pain [83]. In 36-95% of patients, DL has been reported to prevent laparotomy [84]. It is superior to computed tomography or ultrasound of the abdomen in terms of sensitivity and specificity. In BDL, morbidity risks are very low (<8%), and no mortality cases were directly attributed to DL. Due to better safety, DL is also preferred over diagnostic peritoneal lavage. However, since mortality rates among patients admitted in the ICU are generally very high, the diagnostic modality's safety cannot be the sole criteria for its use. The suitable diagnostic modality and the conditions of its use in the patients with suspected postoperative IAS should be case-specific and should not be generalized. The decision should be based on the patient's condition, vital signs, surgical resources and expertise available at the hospital.

Diagnostic Peritoneal Lavage (DPL)

Before the availability of advanced CT techniques, DPL used to be a preferred method for diagnosing intra-abdominal pathology in ICU [85-88]. The process is not associated with mortality risk; however, it is reported to have risks such as small bowel/mesenteric injuries, intra-abdominal abscess, bladder punctures, abdominal wall infusions, and reoperation [89, 90]. Complication rates in DPL have been reported in the range of 0.8%–1.7%. This test is considered 100% sensitive and 88% specific; therefore, a negative diagnostic peritoneal lavage makes intra-abdominal surgical disease highly unlikely. On the other hand, a positive lavage may require further diagnostic examination [90, 91]. For critically ill ICU patients, Lee *et al*. recommended that DPL be a useful preoperative diagnostic tool for examining suspected intra-abdominal pathology [92]. As stated above for BDL, a patient-specific risk-benefit analysis needs to be conducted before selecting DPL for critically ill patients with suspected postoperative IAS. One of the reasons the author has a low threshold for leaving intra-abdominal drains in high-risk patients is to utilize the drain body fluid analysis as a DPL.

Abdominal Reoperation Predictive Index (ARPI)

Though surgeons can use the techniques mentioned above to better assess the severity of intra-abdomen sepsis and decide on reoperation, none of them is exclusively designed to assist in the decision-making process in postoperative IAS. ARPI is the only predictive index available exclusively for the abdominal reoperation decision-making process in postoperative IAS [27, 93]. A typical flow chart for ARPI is shown in figure 2. ARPI has been reported to lower mortality, reduce the delay between the first operation and reoperation, and shorten the duration of ICU stay [27]. ARPI is calculated using the different parameters listed in table 2[27]. It has been claimed that with the proper use of ARPI, the surgical conundrum associated with the decision of reoperation of the patients suspected with postoperative IAS can be resolved to a great extent [27]. ARPI is reported to be specifically useful in settings with limited resources[94]. In a cross-sectional, retrospective study of 94 patients diagnosed with abdominal sepsis, ARPI was used to assist in the decision process[23]. The authors reported reoperation in 75% of cases when ARPI was greater than 21 and 26% of

cases when ARPI was less than 20. In another recent study, ARPI was found to be a helpful surgical decision aid regarding relaparotomy [23]. ARPI, however, also has several limitations. The most important is that the accuracy of this scoring system has not been fully established. Furthermore, the variables that have high weightage are related to postoperative IAI symptoms rather than peritonitis symptoms. The index also has subjective variables such as altered levels of consciousness and abdominal pain, which are difficult to be measured in sedated and ventilated ICU patients [93].

Exploratory laparotomy

Abdominal exploration can also be used as a highly effective diagnostic modality in acute cases of IAS[95-97]. It is a rapid, cost-effective, and accurate method. However, the long-term mortality and morbidity risks associated with it dictate its use only in cases with apparent anticipation of the diagnosis[98-103]. Advances in laparoscopic and imaging techniques for abdomen inspection have further reduced the necessity of exploratory laparotomy. Before exploratory laparotomy, it is essential to ensure that necessary expertise and resources are available to perform the adequate and timely therapeutic procedure if the suspected IAS gets confirmed on exploration[59]. DPL can be used as the first-line of diagnostic modality. If the results are positive, exploratory laparotomy can be used; in case of negative DPL findings, the patient can closely be monitored till the indications for exploratory laparotomy are more evident[104]. In a critical study on exploratory laparotomy, BSL in the ICU was compared with emergency laparotomy in the operating room. The study reported 77.8% mortality in BSL and 45.5% in laparotomy[105]. This result does not suggest that BSL has higher mortality risks than laparotomy. This result underscores the ICU setting's mortality risk and the importance of timely and adequate surgical intervention. In cases where there are no rapid ways available to support the surgical decision process, emergent laparotomy may be used to identify surgically correctable causes, despite the anticipated high mortality with laparotomy[62, 105-107].

Further stressing the importance of timely interventions, some studies recommend on-demand relaparotomy within 48 hours of initial surgery or before the emergence of multiple organ dysfunction syndromes [25, 108-110]. In terms of deciding for relaparotomy, van Ruler *et al*. suggested that findings at emergency laparotomy for peritonitis are not adequate, and the monitoring of progressive or persistent organ failure are the best indicators for the need for reoperation[111]. In the absence of extensive studies, it is difficult to make a conclusive argument. However, all studies in this area recognized the benefits of sensitive detection techniques that permit directed laparotomy before septic deterioration [13, 102, 112, 113].

Serial Intra-abdominal pressure

IAS is reported to be associated with higher intra-abdominal pressure (IAP). IAP increase is ascribed to excessive bowel edema due to increased vascular permeability and fluid sequestration[114, 115]. IAP has been classified into four grades, and higher IAP commonly results in reduced regional and global perfusion, posing a severe risk to vital organ failure. After a comprehensive literature search, Plantefeve *et al*. concluded that IAP could be a useful tool for monitoring critically ill patients with a suspicion of postoperative IAS [116]. Basu *et al*. investigated the predictive potential of the increased IAP for relaparotomy. A study of 102 patients found that postoperative elevation in IAP is associated with the increased risk of peritonitis, concluding that the

elevated IAP can be a predictor of early relaparotomy [117]. It is worth highlighting here that the IAP measurements conducted in the immediate postoperative period were used for predicting the need for relaparotomy. This will be particularly helpful in starting early intervention for the surgical correction of sepsis.

Other notable developments

Using preoperative and intraoperative parameters, Kong *et al*. also reported developing a clinical model with a predictive value of more than 90% for the need for relaparotomy. In a study involving 1000 patients, four factors were used to accurately predicted the need for subsequent relaparotomy. These factors were patients referred from any rural center, duration of illness greater than 5 days, heart rate higher than 120 bpm, and perforation associated with generalized IAS [118]. van Ruler *et al*. used a 10-point visual analog scale (VAS), and VAS score >5.0 was considered 'important.' However, only three out of ten 'important' variables were found to be independently predictive[119]. In another interesting study, postoperative procalcitonin (PCT) serum levels were monitored. The authors claimed sensitivity of 93 % and a specificity of 71 % for eliminating the septic abdominal focus [120]. Sileikis *et al*. devised a scoring system using six factors: age, sex, leukocyte count, C reactive protein, time of symptoms to index operation, and MPI. A score ≥ 37 indicates a planned relaparotomy, and ≤24 indicates other milder therapeutic interventions rather than relaparotomy[121].

CONCLUSIONS

Postoperative IAI can rapidly progress to severe sepsis and septic shock. Patients with postoperative IAS are hemodynamically unstable, and the decision to perform a reoperation to correct the infection surgically is complicated due to the associated high morbidity and mortality risk. The on-demand strategy seems a valid option in such conditions; however, the severity of IAS is not well defined, and it can rapidly progress into an advanced stage where the correction by relaparotomy can become more complicated or not possible. There is a need for diagnostic tools and guidelines that can aid in such a decision process whether to operate or not. The limited timeframe between initial surgery and reoperation and a lack of proper score and indices to support the surgical decision are the significant challenges in the successful management of postoperative IAS. Abdominal CT is the most sensitive imaging modality in the assessment of postoperative intra-abdominal infections. However, in a critical care setting, patients' movement is restricted to allow the transfer of the patient from ICU to the CT room.Furthermore, such an exercise may disrupt or delay the ongoing treatment and may pose a serious morbidity risk. Though available, a portable CT scan is expensive, and the clinical data available on the diagnostic efficacy is limited. Bedside diagnostic laparoscopy is a promising technique with high sensitivity and specificity. Diagnostic peritoneal lavage offers 100% sensitivity, and therefore a negative DPL is an essential tool for surgeons to decide the further course. Exploratory laparotomy is an accurate method, though it poses high morbidity and mortality risks. Wherever possible, a DPL positive test should be used to decide on the requirement of exploratory laparotomy. ARPI is the only predictive tool designed exclusively to assist in the decision process for postoperative IAS. Though the effectiveness of ARPI has been reported in a few studies, more efforts are needed on its validation. IAP has also been advocated to use a part of the assessment tool in such conditions. These factors suggest no single tool available for the surgical decision-making process in patients with postoperative IAS. In the personal author

experience, patients in whom the physical examination is unreliable e.g., intubated and sedated patients, morbidly obese patients, patients with the insensate abdomen, and immunocompromised patients, with a hostile CT abdomen, and who have other sources of sepsis, the author prefers DPL, followed by DL and exploratory laparotomy, in that descending order, however, for patients in whom the physical examination is reliable, immunocompetent, and multiple sources of sepsis and negative CT abdomen, the author prefers a combination of ARPI, Serial IAP measurements, and Drain body fluid analysis if a drain was left from the previous surgery. For patients with no other suspected sepsis source and a negative CT abdomen, the author prefers DL for stable enough patients to go to OR, and DPL for patients who need some resuscitative measures before going to OR, e.g., coagulopathy that requires blood components therapy before surgery. Due diligence to patients' condition, timeframe, and risk associated with the diagnostic modalities should be given before deciding on the preoperative approach.

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Originality/value

This research considers the first attempt for exploring and evaluating the current status of potency and efficacy pof diagnostic methods used for IAS.

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Table 1. Quick Sequential Organ Failure Assessment (qSOFA) score.

Criteria	**Points**
Respiratory rate (≥22/min)	1
Change in mental status	1
Systolic blood pressure (≤100 mmHg)	1

Table 2. Abdominal Reoperation Predictive Index (ARPI).

Criteria	**Score**
Emergency surgery (at primary operation)	3
Respiratory failure	2
Renal failure	2
Ileus (72 hours post-surgery)	4
Abdominal pain (48 hours post-surgery)	5
Wound infection	8
Alterations in the consciousness	2
Persistent symptoms (4th-day post-surgery)	6

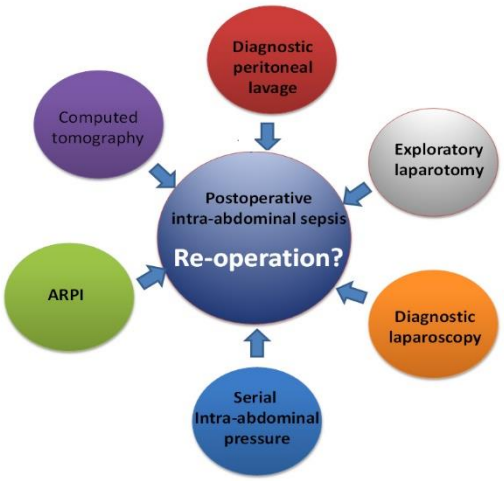

Figure 1. Common diagnostic techniques that assist the surgical decision process in abdominal reoperation in a critical care setting.

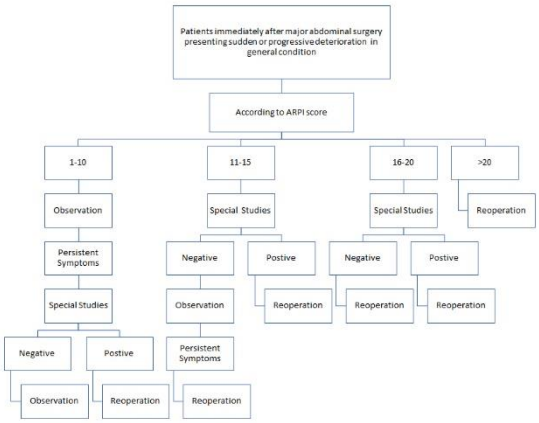

Figure 2. Typical ARPI flow chart (Special studies imply laboratory assays and imaging tests).