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Physiopathology and clinical considerations of laparoscopic surgery in the elderly

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ABSTRACT

Objective: The marked improvements in medical technology and healthcare, lead an increasing number of elderly patients to take advantage of even complex surgical. Recently, laparoscopic surgery has been accepted as a minimally invasive treatment to reduce the morbidity after conventional surgery, and a number of studies have demonstrated the feasibility of laparoscopy with significant advantages also in the elderly. On the other side, the laparoscopic procedure has some drawbacks, including prolonged operation time and impact of carbon dioxide pneumoperitoneum on circulatory and respiratory dynamics. This paper will review the physiopathological implications of laparoscopy, as well as the current literature concerning the most common laparoscopic procedures that are increasingly performed in elderly patients.

Materials and methods: A systematic review of the current literature was performed using the search engines EMBASE and PubMed to identify all studies reporting the physiopathological implications of laparoscopy in the elderly. The MeSH search terms used were "laparoscopy in the elderly", "physiopathology of laparoscopy", and "pneumoperitoneum". Multiple combinations of the keywords and MeSH terms were used with particular reference to elderly patients.

Results: Although laparoscopy is minimally invasive in its dissection techniques, the increased physiologic demands present particular challenges among elderly patients.

Conclusions: Laparoscopy and its safety in the elderly patients remains a challenge and the evaluation of this approach is therefore mandatory. Although many studies have demonstrated the applicability and advantages of the laparoscopy also in the geriatric population, with low rates of morbidity and mortality, in elderly patients undergoing general surgical procedures the physiologic demands of laparoscopy should be carefully considered.

1. Introduction

Citing figures from the World Health Organization, the proportion of elderly people aged 65 years or more was 9.9% and life expectancy is currently 74.4 years for men and 81.8 years for women because of recent improvements in early diagnosis and a well-developed mass-screening program [1,2]. With improved life expectancy the proportion of people surviving their 80s is predicted to rise proportionally in Western countries [3].

Moreover, the marked improvements in medical technology and healthcare, lead an increasing number of elderly patients to take advantage of even complex surgical procedures and we can expect that the number of elderly patients operated on electively or in an emergency setting will follow the same tendency.

The introduction of laparoscopic surgery in 1987 and its widespread use has increased the number of elderly patients undergoing this surgical approach. The general trend in general surgery for the past 25 years has been the shift from conventional surgical procedures towards minimally-invasive alternatives. Recently, laparoscopic surgery has been accepted as a minimally invasive treatment to reduce the morbidity after conventional surgery, and a

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number of studies have demonstrated the feasibility of laparoscopy also in the elderly [4–8].

The elderly in fact represent a unique surgical challenge because of the associated complex comorbidity and diminished cardiopulmonary reserve. Where feasible, laparoscopic surgery is becoming the gold standard in the treatment of many common pathologies that affect elderly patients and may have a larger impact compared to the younger population. It is therefore imperative that general surgeons are comfortable with the management of elderly patients and their surgical pathologies. Given the prevalence of this particular operative procedure, it is clear that factors that influence outcomes, especially when morbidity is added to the vast number and the high costs of laparoscopic procedures, will have a large impact on healthcare expenditures.

This paper will review the physiopathological implications of laparoscopy on the elderly, as well as the current literature concerning the most common laparoscopic procedures that are increasingly performed on these patients.

2. Physiopathological implications of laparoscopy

Recent advances in laparoscopic surgery have benefited patients by a minimally invasive procedure. On the other side, laparoscopy has some disadvantages, including prolonged operation time and impact of carbon dioxide pneumoperitoneum on circulatory and respiratory dynamics [9–15].

Carbon dioxide, the most widely used gas in laparoscopy, has the advantage of being quickly absorbed and excreted, inexpensive and non-flammable. When insufflated into the abdominal cavity, carbon dioxide normally diffuses across the peritoneum, and is carried by the circulation to the lung, where it is expired [16]. However, some adverse effects have been associated with the increased systemic carbon dioxide load manifested by recordable increases in arterial PCO2 after laparoscopy [17,18]. The establishment of pneumoperitoneum is generally associated with increased cardiac filling pressures and an increase in blood pressure and systemic vascular resistance [19–21]. To overcome the increase in systemic vascular pressure healthy patients can increase the contractility of the heart [22].

While most of these changes do not result in clinical significance, they can assume considerable importance in patients with comorbid conditions, especially those that result in decreased cardiopulmonary reserve, as are common in elderly patients.

CO2 absorption is a problem associated with laparoscopic surgery, which can cause significant morbidity, in patients with severe cardiopulmonary disease, if alveolar ventilation is not increased sufficiently to avoid hypercarbia and significant acidosis [23,24].

For cardiopulmonary compromised patients it can be difficult or even impossible to increase the contractility of the heart and they are therefore prone to develop cardiac failure during pneumoperitoneum [25,26].

Furthermore, despite laparoscopic surgery is being widely accepted and generally considered safe, there have been several reports of mesenteric ischemia and bowel infarction after routine laparoscopic procedures. Most of these complications have occurred in patients with evidence of preoperative cardiovascular, hepatic or renal compromise [27,28].

“The higher the pressure, the better the view” is the axiom often cited by surgeons who needed adequate exposure for laparoscopic procedures, but the maintenance of elevated intra-abdominal pressure for the duration of the procedure could be unfortunately associated with numerous undesirable consequences.

Particularly elderly patients exhibit a decline in reserve including cardiopulmonary function, and the impact of pneumoperitoneum in such patients is not fully elucidated.

Intra-abdominal hypertension is usually defined as an intra-abdominal pressure of 12 mmHg or more and is already sufficient an increasing pressure from 10 to 15 mmHg, as usually used in laparoscopy, as well as operating time, to significantly decrease the splanchnic blood flow even at a constant intra-arterial pressure [29,30].

Related to the technical complexity and length of laparoscopic procedures, organ ischemia-reperfusion injury and oxidative stress associated with pneumoperitoneum may become a more significant problem.

Several significant respiratory system changes during laparoscopic surgery are often reported. In studies of patients undergoing laparoscopy under local anesthesia, the patients responded to intraperitoneal CO2 with hyperventilation [31]. Abdominal CO2 insufflation elevates the intra-thoracic pressure and adjusting patient positions by the head-up or head-down tilt results in a change in pulmonary compliance [32,33].

Intra-abdominal pressure may also transfer across the diaphragm into the thoracic cavity, which can increase gastroesophageal reflux and aspiration risk in susceptible patients. Furthermore, this transfer can be further increased by Trendelenburg positioning [25].

Moreover the maintenance of this positions for several hours can lead to expression of edema of the head, the neck and the upper airway with reduction in pulmonary compliance and severe dyspnea [34–36]. In order to avoid ventilatory leak during mechanical ventilation and to prevent aspiration, especially for patients in head-down position, maintenance of adequate endotracheal tube cuff pressure is important [37].

A further aspect is represented by the enzymatic alterations in the liver. The level of serum Aspartate-aminotransferase (AST), Alanine-aminotransferase (ALT), and often also total bilirubin (TBL) usually increased significantly during the first 24 h after laparoscopic surgery. The effects are transient and reverted back to normal within a few days post operation. The major causative factor seemed to be the CO2 pneumoperitoneum [38,39]. In most of the laparoscopic surgery patients, the transient elevation of serum liver enzymes showed no apparent clinical implications but particular care should be paid in patients with pre-morbid liver disease or severe hepatic impairment [40,41].

3. Common laparoscopic procedures in the elderly

Regarding the therapeutic approaches, the excellent results achieved with the use of laparoscopy for cholelithiasis, laid the foundations to the modern use of this surgical technique in a variety of diseases [42–44]. Here we briefly analyze the most common laparoscopic procedures that particularly affect the elderly.

3.1. Laparoscopic cholecystectomy

About 20% of the abdominal surgical procedures performed in those older than 80 years are hepatobiliary [45,46]. Although the prevalence of gallstone formation increases with age and many studies have examined the results of laparoscopic cholecystectomy in elderly patients [47–50], the treatment of gallstone disease in this age group is a challenging [51,52]. This group of patients has in fact an incidence up to 55% of complicated gallstone disease, such as acute cholecystitis, jaundice, choledocholithiasis, cholangitis, and gallstone pancreatitis [48,53]. Both acute cholecystitis and old age are significant risk factors for mortality and prolonged hospital stay after open cholecystectomy [54,55]. Acute biliary disease in the elderly is associated with a considerable increase in operative morbidity and mortality, when compared with non elderly patients [56–58]. Laparoscopic cholecystectomy is currently the procedure

of choice for managing gallstone disease with physiological benefits and positive socioeconomic effects over the open procedure [50,57,59,60]. Many studies have demonstrated the applicability and advantages of the laparoscopic cholecystectomy also in the geriatric population [45–47,61–63] whereas open cholecystectomy has consistently demonstrated higher rates of morbidity and mortality and greater lengths of hospital stay than the general population [54,61,62]. Therefore, a more aggressive approach to symptomatic cholelithiasis in the form of elective surgery is well founded.

3.2. Laparoscopic abdominal wall defect repair

Hernia repair has improved over the past 20 years, but it is still associated with significant morbidity and recurrence. Simple closure of the defect involving re-approximation of fascial edges under tension is associated with a high rate of hernia recurrence. The introduction of the prosthetic mesh to ensure abdominal wall strength without tension has decreased the recurrence rate [64]. In comparison studies, mesh repairs have proven superior to primary repair, with recurrences of 11 and 21% compared to 25 and 52% for simple closure [65].

Incisional hernia repair is among the most common operative procedures performed by plastic and general surgeons and should not be considered a low-risk operation [66,67]. In fact these operations often involve concurrent intra-abdominal procedures, collaboration between multiple surgical teams to achieve fascial closure and the placement of mesh for reinforcement of the repair [65,68]. However, studies have demonstrated the safety and efficacy of this surgical procedures but have had relatively young patient populations, few focused upon the feasibility in the elderly [69–71].

The higher incidence of incisional hernias in the elderly could be attributed to several factors and is thought to be a multi-factorial process [72]. However, the etiology of this common disorder is not well understood and several risk factors for early development of incisional hernia such as wound infection and suture technique have been suggested [73]. Elderly patients, especially those older than 80 years old, are always associated with several comorbid diseases and higher ASA scores, thus putting these patients at a greater risk of intra- and post-operative complications that are able to favor the formation of the incisional hernia [74].

Laparoscopic abdominal approach seems to have a positive impact with a marked reduction in the rate of incisional hernia even if this surgical procedure is not immune to complications. The minimally invasive approach and the lower incidence of wound infections, restricts the possibility of incisional hernia at the trocar site [75,76]. The steady increase of this particular incisional hernia, resulting in the laparoscopic access, is strictly correlated to the growing number and complexity of laparoscopic procedures. This complication often requires further surgical intervention to repair the wall defect and can in turn be associated with considerable morbidity [77,78]. The incidence of port-site herniation is estimated to be between 0.7 and 2.8% but it is commonly accepted that without medium-term to long-term follow-up, most asymptomatic cases will remain undiagnosed [79,80].

3.3. Laparoscopic colon resection

The incidence of both benign and malignant disease of the colon increases with chronological age and a number of series attesting the safety and benefits of laparoscopic colorectal resection in the elderly have been published underlining the oncologic equivalence of treatment between laparoscopic resection and open procedures [81–83].

Overall, pulmonary and cardiovascular complications might be reduced after a laparoscopic procedure in elderly patients, as well as a lower blood loss, early return of intestinal motility reduced postoperative recovery, early discharge to rehabilitation and improved long-term survival compared to the open colorectal surgery [3,84–86].

Moreover, laparoscopic surgery reduces alterations of general and immunological conditions of operated patients when compared to traditional surgery, probably reducing postoperative tumor growth [87–89].

Several clinical trials emphasized aforementioned benefits, leading to a general agreement on laparoscopic surgery as an alternative to conventional open surgery for colon cancer.

However, despite the theoretical advantages of laparoscopic surgery, it is still not considered the standard treatment for colorectal cancer due to technical limitations and the characteristic of the patients that may affect short and long-term outcomes.

4. Discussion

In the last decade of surgical evolution and in the decades to come, health trends will be determined mainly by the ageing of the world's population. Laparoscopy and its safety in this age group in a daily practice remains a challenge and the evaluation of this approach is therefore mandatory. Considering this, an important scoring system as the POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) and the modified Portsmouth POSSUM (P-POSSUM), successfully used by many authors even for surgical audits in developing countries, should be taken into account [90,91].

The primary goals of any minimally invasive surgical technique are to achieve minimum derangement in homeostasis and minimal pain without compromise in safety or outcome of the procedure. The standard method of laparoscopy is by creating pneumoperitoneum using a pressure regulating automatic insufflator. The maintenance of elevated intra-abdominal pressure for the duration of the procedure is associated with numerous adverse effects, mostly attributed to the positive intraperitoneal pressure [92–95]. It is important to note that corresponding open abdominal procedures are also associated with a similar oxidative stress response, indicating that this phenomenon is not simply due to increased intra-abdominal pressure [18].

However the clinical significance of the oxidative stress caused by pneumoperitoneum in patients with significant co-morbidity, particularly those with cardiovascular compromise, therefore needs further investigation.

Physiopathological changes caused by the pneumoperitoneum can be managed with invasive monitoring and resulting therapy [25,26] and simple measures, that might reduce its impact in situations where physiological reserves are compromised, were highlighted by many Authors.

The increase in systemic vascular resistance with reduction in cardiac output can be kept to a minimum using low intra-abdominal pressures (8–10 mmHg) under adequate muscular relaxation. In order to reduce hemodynamic compromise; it is recommended that the lowest possible inflation pressure is used without compromising visibility [96,97].

Since the beginning of the 1990s, gasless surgery has also been employed. There have been several different methods of elevating the abdominal wall without the use of gas insufflation [98,99]. One of the most widely employed systems has been the LaparoliftTM [100], in which an intraperitoneal fan-shaped retractor is used to lift the abdominal wall, although this may not provide uniform exposure and increases operating time [96,101].

Intravascular volume expansion with intravenous fluids before

commencement of pneumoperitoneum can enhance renal perfusion and reduce the extent of renal injury [102].

During pneumoperitoneum, gas exchange without any hemodynamic effects, in patients undergoing laparoscopic procedures were improved applying appropriate positive end-expiratory pressure to corresponding intra-abdominal pressure [103].

The undeniable advantages obtained by minimally invasive approach and the benefits in term of outcome, have allowed the application of this surgical technique routinely in many of the diseases that affect the elderly patient. Many studies are in fact now available in the scientific literature which confirm the feasibility and safety of these surgical procedures even in aged patients.

As previously described laparoscopic cholecystectomy, laparoscopic abdominal wall defect repair for primitive or incisional hernias, colorectal laparoscopic surgery and further surgical procedures are now present in everyday surgical practice of many centers [104–107].

Moreover, since the laparoscopic approach limits the tissue trauma and leads to significant less physiologic alterations during the perioperative period, with preservation of the immunologic function [87,88], may be translated in better long-term outcomes and may be correlated with preventing cancer recurrence and higher postoperative survival rates in oncologic disease [108,109].

5. Conclusions

Currently patients older than 65 years represent over 40% of all surgeries performed. This figure is expected to increase substantially over the coming decades, with a complementary increase in surgical demand. Laparoscopy and its safety in this age group in a daily practice remains a challenge and the evaluation of this approach is therefore mandatory. Although laparoscopy is minimally invasive in its dissection techniques, the increased physiologic demands discussed above present particular challenges among elderly patients. There is some evidence that the use of carbon dioxide as the insufflation gas may be contributory, although the impact of other factors such as the temperature and humidity of the gas have not been elucidated.

A number of measures have been proposed to reduce oxidative stress caused by pneumoperitoneum, although some of these measures have shown promise in animal studies, few have been evaluated in the clinical setting. Although many studies have demonstrated the applicability and advantages of laparoscopy also in the geriatric population, with low rates of morbidity and mortality, in elderly patients undergoing general surgical procedures the physiologic demands of laparoscopy should be carefully considered.

Ethical approval

Ethical approval was not requested.

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Author contribution

Pietro Caglià: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Angelo Tracia: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Antonino Buffone: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Luca Amodeo: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Luciano Tracia: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Corrado Amodeo: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Massimiliano Veroux: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Conflicts of interest

All Authors have no conflict of interests.

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