

Clinical Guideline

Pneumoperitoneum for Laparoscopic Surgery

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Introduction

Only fifteen years after the introduction of laparoscopic cholecystectomy, laparoscopic techniques (used either as a diagnostic tool or therapeutic access method) are among the most common procedures in surgery worldwide. However, concerns about higher surgical complications rates (such as vascular and intestinal injuries as compared to conventional techniques) and anaesthesiological risks have remained. Since the start of the laparoscopic era, numerous of studies have described pathophysiological or clinical problems that are related to laparoscopy. Therefore, many technical innovations and modifications have been developed to improve safety and effectiveness of laparoscopy, but not all of them have been studied adequately before clinical use.

Having these developments in mind, the European Association for Endoscopic Surgery (EAES) decided to develop authoritative and evidence-based clinical practice guidelines on the pneumoperitoneum and its sequelae. The scope of these guidelines covers all important general surgical aspects of the pneumoperitoneum, but not special laparoscopic procedures for defined pathologies. It addresses the pathophysiological basis for the clinical indications (part I), aspects to establish the pneumoperitoneum (part II), and perioperative aspects such as adhesions and pain (part III). In addition a clinical algorithm was formulated for practical use.

Methods

Under the mandate of the EAES Scientific Committee with the aim to set up evidence-based clinical practice guidelines, we combined the methodologies of a systematic review and a consensus development conference (CDC), because previous CDCs (both within and outside the EAES) had difficulties in identifying all relevant articles. As a framework of the process, the key aspects pertaining to the pneumoperitoneum were precisely formulated in separate questions, which then were answered concurrently by the use of literature and expert evidence.

For the systematic review, one researcher (J.N.) performed comprehensive literature searches in Medline, Embase and the Cochrane Library. We combined the medical subject headings "Laparoscopy" or "Pneumoperitoneum" with free-text terms. Our primary intention was to identify all clinical relevant randomized controlled trials (RCTs). However, other trials using concurrent cohorts (CCTs), external or historical cohorts, population-based outcomes studies, case series and case reports were accepted for a comprehensive evaluation of the pneumoperitoneum and its sequelae (see **Table 1**). Included articles were scrutinized and classified by two reviewers (J.N. and S.S.). Furthermore, all panelists were asked to search the literature themselves according to a list of defined questions. The reference lists of all relevant articles were additionally checked.

For the CDC, the conference organisers in Cologne together with the scientific committee of the

E.A.E.S. nominated a multi-disciplinary expert panel. The criteria for selection were clinical and scientific expertise in the field of laparoscopy and geographical location within Europe.

Half a year before the conference, the questions on laparoscopy were sent out to the panelists. In parallel, the questions were answered by literature evidence found in systematic searches. One month before the conference, all answers from the panel and the literature searches were analyzed and subsequently combined into a provisional preconsensus statement and a clinical algorithm. Each panel member was also informed about the identity of the other members, which had not been disclosed thus far.

In Maastricht, all panelists met for a first meeting on June 13th. Here the provisional bottom line statements typed in bold and the clinical algorithm with the grades of recommendation were scrutinized word by word in a 9 hour session in a nominal group process (NGP). For all statements, internal (expert opinion) and external evidence were considered. The following day the modified statement and the algorithm were presented to the conference audience by all panelists for public discussion (1½ hour session). During a post-consensus meeting on the same day, all suggestions from the audience were discussed again by the panelists, and the statement was further modified. The finalized statement as given below was mailed to all panelists for final approval (Delphi process) before publication.

To increase readability also, a short version of the clinical practice guidelines with a clinical algorithm was prepared (see appendix). The extended version consists of a detailed appraisal of pathophysiologic background and clinical research evidence.

I. Pathophysiological basis for the clinical indications

1. Cardiovascular system

Cardiovascular effects of pneumoperitoneum occur most often during its induction, and this should be considered when initial pressure is raised for introduction of access devices. In ASA I-II patients, the haemodynamic and circulatory effects of a 12 - 14 mmHg capnoperitoneum are generally not clinically relevant (grade A). Due to the haemodynamic changes in ASA III-IV patients, however, invasive measurement of blood pressure or circulating volume should be considered (grade A). These patients also should receive adequate preoperative volume-loading (grade A), beta-blockers (grade A), and intermittent sequential pneumatic compression of the lower limbs, especially in prolonged laparoscopic procedures (grade C). If technically feasible, gasless or low-pressure laparoscopy might be an alternative for patients with limited cardiac function (grade B). The use of other gases (e.g. helium) showed no clinically relevant haemodynamic advantages (grade A).

2. Lung physiology and gas exchange

Carbon dioxide pneumoperitoneum causes hypercapnia and respiratory acidosis. During laparoscopy, monitoring of end-tidal CO₂ concentration is mandatory (grade A) and minute volume of ventilation should be increased in order to maintain normocapnia. Increased intraabdominal pressure and head-down position reduce pulmonary compliance and lead to ventilation-perfusion mismatch (grade A). In patients with normal lung function, these intra-operative respiratory changes are usually not clinically relevant (grade A). In patients with limited pulmonary reserves, capnoperitoneum carries an increased risk of CO₂-retention, especially in the postoperative period (grade A). In patients with cardiopulmonary diseases, intra- and postoperative arterial blood gas monitoring is recommended (grade A). Lowering intraabdominal pressure and controlling hyperventilation reduce respiratory acidosis during pneumoperitoneum (grade A). Gasless laparoscopy, low-pressure capnoperitoneum, or the use of helium might be an alternative for patients with limited pulmonary function (grade B). Laparoscopic surgery preserves postoperative pulmonary function better than open surgery (grade A).

3. Venous blood return

During laparoscopy, both head-up position and elevated intra-abdominal pressure independently reduce venous blood return from the lower extremities (grade A). Intraoperative sequential intermittent pneumatic compression of the lower extremities effectively reduces venous stasis during pneumoperitoneum (grade A/B) and is recommended for all prolonged laparoscopic procedures. The true incidence of thromboembolic complications after pneumoperitoneum is not known.

4. Perfusion of intraabdominal organs

Although in healthy subjects (ASA I-II), changes in kidney or liver perfusion (grade A) and also splanchnic perfusion (grade D) due to an intraabdominal pressure of 12-14 mmHg have no clinically relevant effects on organ function, this may not be the case in patients with already impaired perfusion. Especially, in patients with impaired hepatic or renal function or atherosclerosis, the intraabdominal pressure should be as low as possible to reduce microcirculatory disturbances (grade B). Patients with impaired renal function should be adequately volume loaded before and during elevated intraabdominal pressure (grade A).

5. Stress response and immunologic parameters

Changes in systemic inflammatory and anti-inflammatory parameters (mainly cytokines) as well as in stress response parameters are less pronounced after laparoscopic surgery than after conventional surgery (grade A). Whether this leads to clinically relevant effects (eg less pain, fatigue and complications), remains to be proven. There is no compelling clinical evidence that specific

modifications of the pneumoperitoneum alters the immunological response.

6. Peritonitis

Presupposing appropriate perioperative measures (e.g. adequate preoperative volume loading) and haemodynamic stability, there are no contraindications to create a pneumoperitoneum when laparoscopic surgery is applicable in cases of peritonitis (grade B). The results from animal studies about the influence of pneumoperitoneum upon bacteraemia and endotoxaemia are controversial.

7. Risk of tumor spreading

Until now, there is no strong clinical evidence (except case reports) that pneumoperitoneum in patients with intraabdominal malignant disease increases the risk of tumor spread (grade D). The panel considers there is no reason to contraindicate pneumoperitoneum in these patients, given the fact that an appropriate operative technique is used (grade C). The type of insufflation gas seems to affect intraabdominal tumor growth, while intraabdominal pressure is of little importance (grade D). Due to the low level of evidence, patients undergoing laparoscopic surgery for malignant disease should be included in randomised controlled trials or at least in quality registries.

II. Establishing the pneumoperitoneum

1. Creation of a pneumoperitoneum

For severe complications (vessel perforation) it is impossible to prove a difference between closed and open access technique in RCTs, therefore, large outcome studies should be considered. In the RCTs, the rate of major and minor complications is surprisingly high, which may be due to the definition of a complication or surgical learning curve. Insertion of the first trocar with the open technique is faster as compared to the Veress needle (grade A). The randomised controlled trials comparing closed (Veress plus trocar) versus open approach have inadequate sample size to find a difference in serious complications. In large outcomes studies there were less complications in the closed group (grade B). Although RCTs found the open approach faster and associated with a lower incidence of minor complications (grade A), the panel cannot favour the use of either access technique. However, the use of either techniques may have advantages in specific patient subgroups (grade B).

2. Gas embolism and its prevention

Clinically relevant gas embolism is a very rare, but if it occurs, may be a fatal complication (grade C). The true incidence of clinically inapparent gas embolism is not known. Most cases of gas embolism described have been caused by accidental vessel puncture with a Veress needle at the induction of pneumoperitoneum. Low intraabdominal pressure, low insufflation rates, as well as careful surgical

technique may reduce the incidence of gas embolism (grade D). A sudden drop in end tidal CO₂ concentration and blood pressure during abdominal insufflation should be considered a sign of gas embolism (grade C). Due to the low incidence of clinically relevant gas embolisms, an advanced invasive monitoring (transoesophageal Doppler sonography) cannot be recommended for clinical routine (grade B).

3. Choice of insufflation pressure

The panel recommends to use the lowest intraabdominal pressure allowing adequate exposure of the operative field, rather than using a routine pressure (grade B). An intraabdominal pressure lower than 14 mmHg is considered safe in a healthy patient (grade A). Abdominal wall lifting devices have no clinically relevant advantages compared to low-pressure (5-7 mmHg) pneumoperitoneum (grade B).

4. Warming and humidifying of insufflation gas

Warming and humidifying insufflation gas is intended to decrease heat loss. Compared to external heating devices, however, the clinical effects of warmed, humidified insufflation gas are minor (grade B). Data on its influence on postoperative pain are contradictory (grade A).

5. Abdominal wall lifting devices

Abdominal wall lifting as compared to capnoperitoneum results in less impairment of haemodynamic, pulmonary and renal function (grade A). In ASA I-II patients, the magnitude of these benefits is too small to recommend (grade D). In patients with limited cardiac, pulmonary or renal function, abdominal wall lifting combined with low-pressure pneumoperitoneum might be an alternative (grade C). Nevertheless, surgical handling and operative view were impaired in most surgical procedures (grade A).

6. Size of access devices

Smaller access devices ($\leq 5\text{mm}$) in laparoscopy is only feasible in a selected group of patients. The use of 2-5mm instead of 5-10mm access devices improves cosmetic result and postoperative pain marginally in laparoscopic cholecystectomy (grade A).

III. Postoperative aspects

1. Adhesions

Some laparoscopic procedures may cause less postoperative adhesions as compared to their conventional counterparts (grade B). However, the specifics of a pneumoperitoneum (gas, pressure, temperature and humidity) seem to have no major effect on the development of postsurgical adhesions (grade D).

2. Pain, nausea and vomiting

Pain after laparoscopic surgery is multifactorial and should be treated with a multimodal approach (grade A). Shape and size of access devices has to be considered (grade A). Low-pressure pneumoperitoneum, heated and humidified insufflation gas, incisional and intraperitoneal instillation of local anaesthetics, intraperitoneal instillation of saline, and removal of residual gas,- all reduce postlaparoscopic pain (grade B). Inconclusive data and small “effect sizes“ of singular approaches make it difficult to recommend these treatments in general (grade D). No evidence exists that the specifics of a pneumoperitoneum have any effect on postoperative nausea and vomiting.

3. Pregnancy

Presupposing obstetrical consultation, laparoscopic procedures during pregnancy should be performed in the second trimester if possible (grade C). Perioperatively, maternal end-tidal CO₂-concentration and arterial blood gases must be monitored to control maternal hyperventilation and to prevent fetal acidosis (grade C). For the establishment of the pneumoperitoneum the open technique should be preferred (grade C). During laparoscopy intraabdominal pressure should be kept as low as possible and body positioning should be considered in order to avoid inferior vena cava compression by the uterus (grade C). Furthermore, pneumatic compression devices are recommended (grade D).

4. Intracranial pressure

Raised IAP and head-down position increase intracranial pressure (ICP) (grade A). Therefore, elevated IAP, head down position and hypoventilation should be avoided (grade D). In patients with head injury or neurological disorders, perioperative monitoring of ICP should be considered (grade C). Gasless laparoscopy might be an alternative to prevent ICP peaks (grade D).

5. Abdominal trauma

Until now, there are no prospective studies evaluating the specifics of a pneumoperitoneum (type of gas, IAP, temperature) in patients with blunt or penetrating abdominal trauma (grade D).

Table 1: A method for grading recommendations according to scientific evidence*

Grade of recommendation	Level of evidence	Possible study designs for the evaluation of therapeutic interventions
A	1a	Systematic review (with homogeneity) of RCTs
	1b	Individual RCT (with narrow confidence interval)
	1c	All or none case series
B	2a	Systematic review (with homogeneity) of cohort studies
	2b	Individual cohort study (including low quality RCT)
	2c	"Outcomes" research
	3a	Systematic review (with homogeneity) of case-control studies
	3b	Individual case-control study
C	4	Case-series (and poor quality cohort and case-control studies)
D	5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles", animal studies

(* Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. Evidence-based medicine: How to practice and teach EBM. (2nd Ed.) London/UK: Churchill Livingstone, 2000.)

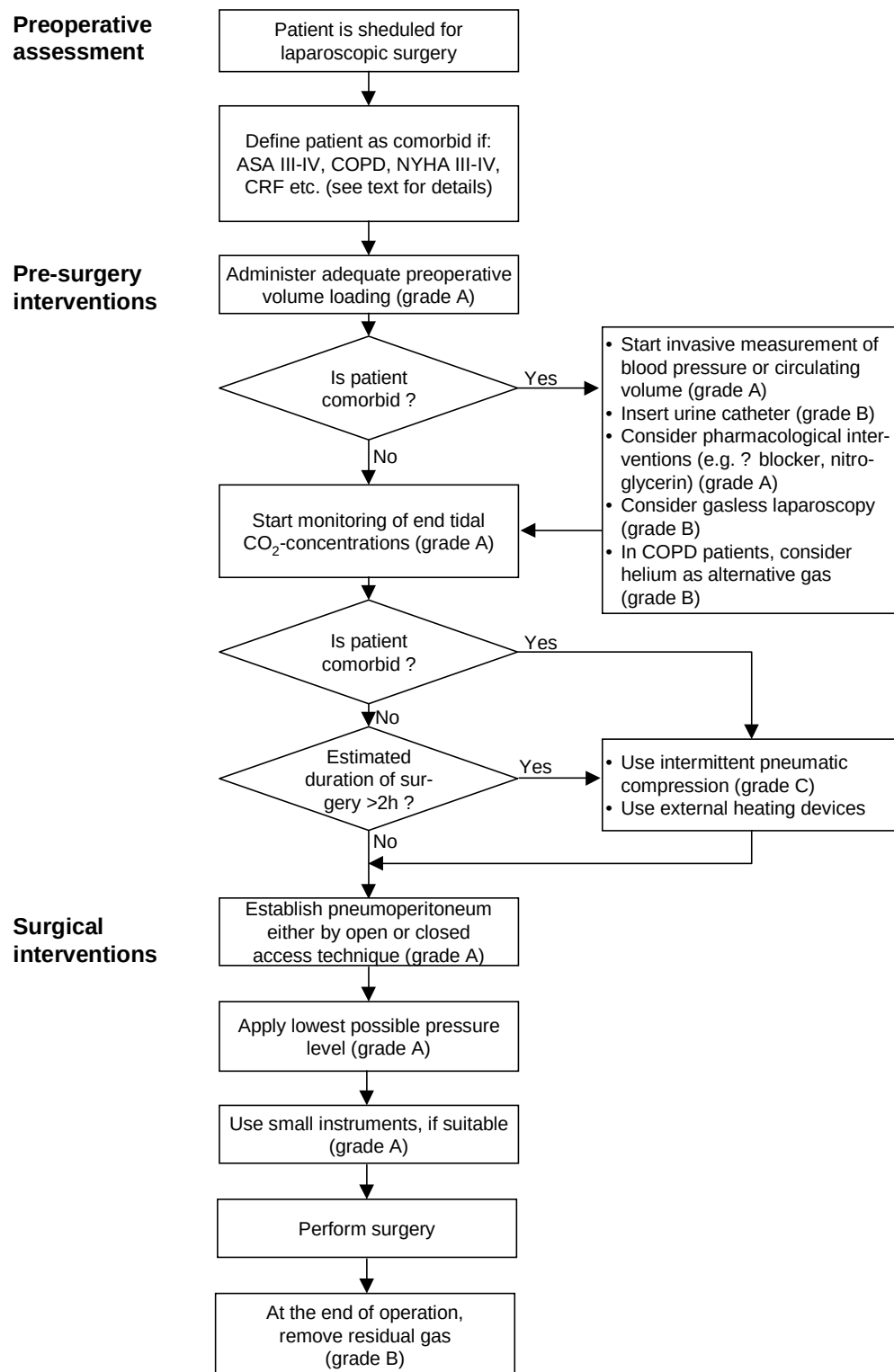


Figure 1: Evidence-based clinical algorithm on the pneumoperitoneum for laparoscopic surgery. The recommendation is graded according to table 1. Diamond boxes = decision boxes; square boxes = action boxes