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Year : 2019

## Anaesthesia in a toxic environment: Pressurized IntraPeritoneal Aerosol Chemotherapy. A retrospective analysis

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Rouche Amir, 2019, Anaesthesia in a toxic environment: Pressurized IntraPeritoneal Aerosol Chemotherapy. A retrospective analysis

Originally published at : Thesis, University of Lausanne

Posted at the University of Lausanne Open Archive <http://serval.unil.ch>

Document URN : urn:nbn:ch:serval-BIB\_73EE8AF0E4E78

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**UNIVERSITE DE LAUSANNE - FACULTE DE BIOLOGIE ET DE MEDECINE**

Département des Services de Chirurgie et d'Anesthésie

Anesthésiologie

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**Anaesthesia in a toxic environment: Pressurized IntraPeritoneal Aerosol  
Chemotherapy. A retrospective analysis**

THESE

préparée sous la direction du Docteur Catherine Blanc

et présentée à la Faculté de biologie et de médecine de  
l'Université de Lausanne pour l'obtention du grade de

DOCTEUR EN MEDECINE

par

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Lausanne  
2019

# *Imprimatur*

*Vu le rapport présenté par le jury d'examen, composé de*

**Directeur de thèse**      *Madame la Docteure Catherine Blanc*

**Co-Directeur de thèse**

**Expert**                      *Monsieur le Professeur Patrick Schoettker*

**Vice-Directeur de  
l'Ecole doctorale**      *Monsieur le Professeur John Prior*

*la Commission MD de l'Ecole doctorale autorise l'impression de la thèse de*

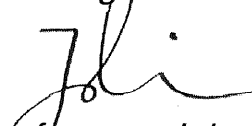
***Monsieur Amir ROUCHE***

*intitulée*

***Anaesthesia in a toxic environment: Pressurized IntraPeritoneal  
Aerosol Chemotherapy. A retrospective analysis***

*Lausanne, le 19 mai 2020*

*pour Le Doyen  
de la Faculté de Biologie et de Médecine*



*Monsieur le Professeur John Prior  
Vice-Directeur de l'Ecole doctorale*



# Anaesthesia in a Toxic Environment: Pressurised Intraperitoneal Aerosol Chemotherapy: A Retrospective Analysis

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*Cite this article as:* Rouche A, Hübner M, Grass F, Pache B, Demartines N, Blanc C. Anaesthesia in a Toxic Environment: Pressurised Intraperitoneal Aerosol Chemotherapy: A Retrospective Analysis. Turk J Anaesthesiol Reanim 2019; DOI: 10.5152/TJAR.2019.15493.

## Abstract

**Objective:** Pressurised intraperitoneal aerosol chemotherapy (PIPAC) is a new type of intraperitoneal chemotherapy for peritoneal carcinosis via minimally invasive surgery. This technique's specificity is the remote application of the therapy because of the potential risk of exposure to toxic products. The present paper summarises the important aspects of PIPAC and analyses the anaesthetic outcomes.

**Methods:** This retrospective study included all patients undergoing PIPAC treatment between January 2015 and February 2018. Data on protocol adherence and perioperative anaesthetic complications and postoperative nausea and vomiting (PONV) and pain levels (visual analogue scale 0–10) from recovery room to 72 h were analysed.

**Results:** The overall analysis included 193 PIPAC procedures on 87 patients. Protocol adherence was high as regards the use of propofol (100%), rocuronium (98%), antiemetic prophylaxis (99%) and lidocaine intravenous (i.v.) (87%). No accidental exposure to chemotherapy occurred during the study period. Of the 87 patients, 6.3% suffered delayed recovery, 58% due to hypothermia and 42% due to excessive sedation or curarisation. In the recovery room, 16% of patients suffered moderate to severe pain, requiring >8 mg of morphine i.v., with average doses of 13.7 mg. Median postoperative pain scores were 1 and 3 at 12 h and 0 and 0 at 72 h at rest and mobilisation, respectively. PONV was observed in <10% of patients during the first 12 h, but in 40% at 72 h.

**Conclusion:** A dedicated anaesthetic protocol and intraoperative safety checklist facilitates safe, well-tolerated anaesthesia for PIPAC treatments.

**Keywords:** Adverse effects, doxorubicin, laparoscopy, peritoneal metastases, pressurised intraperitoneal chemotherapy

## Introduction

Peritoneal cancer (PC) is a challenging pathology to diagnose and treat. Without therapeutic management, expected survival time is <6 months for PC of colorectal origin or primitive diseases of the peritoneum (1-3). Palliative systemic chemotherapy has a 5-year survival of <15% due to low penetration of the agents and a high incidence of complications. Since 1990, hyperthermic intraperitoneal chemotherapy (HIPEC) in combination with cytoreductive surgery (CRS) has improved outcomes, and the median survival time of patients increased to 22.9 months in a selected cohort of patients (4-6). However, CRS+HIPEC is associated with significant morbidity and mortality rates (42% and 3.8%, respectively), even in specialist referral centres, and quality of life (QoL) is impaired for months after the procedure (4, 7, 8). Therefore, only patients in good general condition can be considered for this treatment. Furthermore, HIPEC has important pharmacokinetic limitations, namely single-dose administration and poor distribution and tissue penetration (9).

Pressurised intraperitoneal aerosol chemotherapy (PIPAC) is a new type of intraperitoneal drug delivery which overcomes some of the above limitations (10). It consists of an intraperitoneal application of vaporised aerosol chemo-

The study was presented as an oral communication at the 11<sup>th</sup> International Workshop on Peritoneal Surface Malignancy, September 9–11, 2018, Paris and as a poster at the SSAR Congress, November 8, 2018, Interlaken, Switzerland.

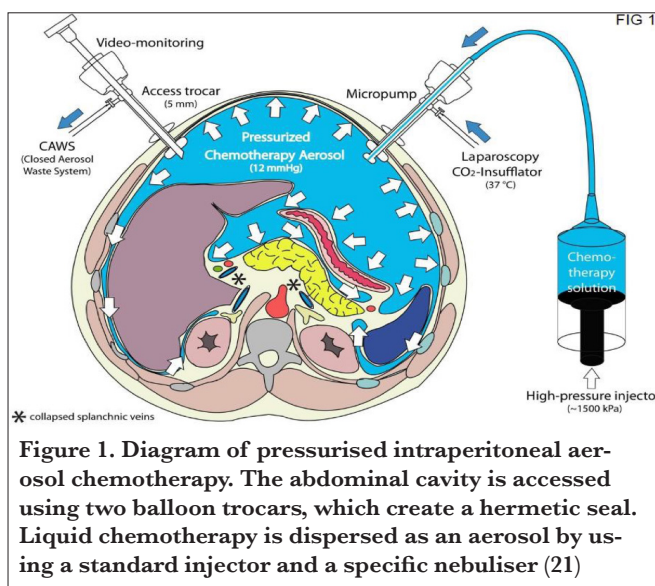
therapy via minimally invasive surgery using a specific nebuliser (CapnoPen®). This approach has been shown to improve distribution and tissue penetration considerably (10-12).

Furthermore, PIPAC can be applied repeatedly, thus increasing the potential to achieve local control of recurrent PC and allowing sequential tumour sampling during laparoscopy. Moreover, chemotherapy doses applied during PIPAC are approximately 10 times smaller than systemic chemotherapy, thus reducing systemic exposure (13).

The present recommendations are for three applications of PIPAC over 3 months. The chemotherapy regimens currently proposed are oxaliplatin alone for colorectal cancer and doxorubicin and cisplatin for PCs of other origins. Platinum agents may induce anaphylactic reactions and can irritate the eyes, skin and airways; they are toxic to the kidneys and bone marrow (14, 15). Doxorubicin provokes mucosal inflammation, leukopenia and dilated cardiomyopathy. Both cytotoxic drugs are carcinogenic to humans (class 2A according to the International Agency for Research on Cancer) (16-19).

Owing to the potential leaks of aerosolised cytostatics, a special safety protocol is needed to reduce exposure risks to healthcare staff. The currently proposed protocol involves the remote administration of chemotherapy, with no direct access to the patient for approximately 30 min. This is particularly challenging for an anaesthesiology team as it requires adaptations to standard protocols for comparable procedures regarding invasiveness and duration, such as laparoscopic cholecystectomy.

Therefore, the aim of the present study was to summarise the important aspects of this particular procedure from the anaesthetic point of view and analyse anaesthetic outcomes.



## Methods

This retrospective analysis included all consecutive patients undergoing PIPAC at Lausanne University Hospital between January 2015 and February 2018. All patients were discussed at multidisciplinary tumour boards, and typical indications were isolated peritoneal disease in patients not amenable to CRS+HIPEC.

The study was approved by Lausanne University Hospital's Institutional Review Board (no. 2016-00274) and conducted and reported in compliance with the STROBE criteria and registered online (<http://www.researchregistry.com>; UIN: 4332). All patients were asked for consent to the use of their anonymised clinical data, via a general consent form, as per Swiss law. Patients refusing to sign the form were excluded from the study.

Anaesthetic protocols and an intraoperative safety checklist and procedure were designed in close collaboration with the surgical team before the study started (20). The anaesthetic protocol and safety checklist are provided as an online Appendix 1.

## Safety considerations

During the study period, the same surgeon was supported by a dedicated team of anaesthesiologists and instrument technicians for all the PIPAC procedures. Owing to the administration of a carcinogenic chemotherapy, pregnant or breastfeeding women were not allowed to enter the operating room (OR).

Pressurised intraperitoneal aerosol chemotherapy was performed in an OR with a laminar flow, as per safety protocol. Before the vaporisation phase, the surgeon and the entire team run through the safety checklist. During and after the administration phase, healthcare staff must wear a high filtration face mask (FFP3), surgical gown, double nitrile gloves and protective glasses to avoid exposure to the skin and mucosa in case of accidental exposure when entering the OR. With these precautions, entry into the OR due to an anaesthetic problem is allowed if urgently required.

## PIPAC procedure

The procedure lasts approximately 90 min and is technically comparable to laparoscopic cholecystectomy (Figure 1). Laparoscopy is performed using a standard pressure of 12 mmHg (CO<sub>2</sub> pneumoperitoneum) using two balloon trocars (21). The first part of the procedure involves an evaluation of the disease extent using the PC index (22). Peritoneal biopsies are obtained, and ascites is removed from the abdominal cavity. Chemotherapy is then vaporised using a high-pressure injector connected to a nebuliser that was de-

veloped specifically for PIPAC. The injector is remote-controlled, allowing the staff to be outside the OR during the administration of intraperitoneal chemotherapy. The drugs are vaporised for 5 min, and then therapeutic CO<sub>2</sub> pneumoperitoneum is maintained for 30 min to allow drug penetration into the tissues. At the end of the procedure, the pneumoperitoneum is exsufflated via the closed aerosol waste system through two sequential microparticle filters into the anaesthetic air waste system.

### **Anaesthetic considerations**

PIPAC patients are given general anaesthesia with standard tracheal intubation. Owing to the patient's inaccessibility during the vaporisation phase, monitoring must be possible from outside the OR to allow remote-controlled drug injection if needed.

### **Positioning and monitoring techniques**

The patient is positioned in the supine position, with legs apart resting on straight pads, allowing the surgeon access between the legs. The left arm is positioned along the body, and the right arm is in abduction at 90° for venous access. A forced air system (Bair Hugger™) is placed over the upper body. In addition to standard anaesthetic monitoring (electrocardiogram, blood pressure, saturation and temperature), depth of anaesthesia is assessed using a bispectral index, and neuromuscular response is closely monitored using a hand accelerometer. These parameters must be available to the anaesthesiologists outside the OR, either through a window or on a second screen. The patient must be kept strictly and continuously immobile during the vaporisation. Two peripheral venous routes are put in place. The first is used for the induction and maintenance of anaesthesia. The second is connected to a long line and is accessible from outside the OR if re-injection is needed.

Before initiating the vaporisation, monitoring, venous access and patient positioning must be reassessed, and the surgical team goes through the operational safety checklist (online Appendix 2).

### **Sedation and curarisation**

Propofol is the preferred choice for the induction and maintenance of anaesthesia, as it reduces postoperative nausea and vomiting (PONV) better than volatile anaesthesia. Furthermore, intravenous (i.v.) anaesthesia enables the use of a closed aerosol waste system for exsufflation of the toxic pneumoperitoneum at the end of the procedure.

Curarisation must last until the end of the procedure to ensure complete patient immobility and constant intra-abdominal pressure with a target post-tetanic count of between 5 and 8–10 measured using an automated accelerometer. Ro-

curonium is preferred for its ability to be quickly reversed by sugammadex if needed.

### **Multimodal pain management**

Standard analgesia based on a medium-acting opioid (fentanyl) is given to patients for intubation and surgery. A continuous infusion of lidocaine i.v. is initiated at induction (bolus 1.5 mg kg<sup>-1</sup>) and continued (2 mg kg<sup>-1</sup> h<sup>-1</sup>) until departure from the recovery room to reduce opioid use and the side effects of nausea and vomiting and to optimise postoperative analgesia. In addition, patients receive a magnesium sulphate infusion at a rate of 40 mg kg<sup>-1</sup> over 10 min.

Postoperative analgesia is based on paracetamol, nonsteroidal anti-inflammatory drugs and morphine on demand for the postoperative period.

### **Prevention of PONV**

The combination of general anaesthesia and chemotherapy can potentially amplify PONV. Therefore, patients receive an association of three antiemetic drugs: droperidol and dexamethasone at the beginning of the procedure and ondansetron before waking up and for the postoperative period. In cases of intense PONV, fosaprepitant was selected as a rescue treatment.

### **Data management**

Demographic, surgical and anaesthetic details for all patients were prospectively entered in a computerised, coded database designed specifically for the quality control of the PIPAC cohort. Demographic data included age, sex, body mass index, American Society of Anesthesiologists and cancer origins. Anaesthetic protocol adherence was analysed with regard to the presence of the dedicated anaesthetic team and the protocol's proposed drug usage. Recorded anaesthetic complications included severe arrhythmia, haemodynamic instability, anaphylaxis, mild hypothermia (defined as a temperature from 32.2°C to 35.5°C), delayed recovery (>15 min after the end of surgery), difficult i.v. access (defined as needing more than two attempts) and moderate to severe pain (defined as needing >8 mg of morphine in the recovery room). For the first 74 PIPAC procedures, patients described their pain using a visual analogue scale, and the incidence of PONV was assessed from the recovery room until 72 h and entered in the quality control database.

### **Statistical analysis**

Statistical analysis was performed using Stata Software (v. 14.2; StataCorp, College Station, TX, USA). Continuous variables were presented as mean±standard deviation or median value with range or interquartile range (IQR), as appropriate, depending on the normality of the distribution.

## Results

A median of 2 (1–7) PIPAC treatments was performed on our 87 patients, with a total of 193 procedures. The cohort’s demographic information is shown in Table 1. The median postoperative length of stay was 2 (IQR 2–3) days.

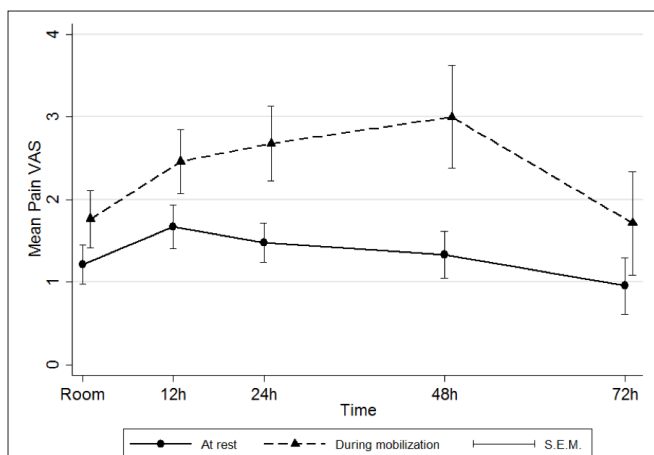
All surgeries were performed by the same surgeon, whereas anaesthesiologists and nurse anaesthetists from the dedicated team were present at 79% and 55% of procedures, respectively. The overall protocol adherence was high with respect to the use of propofol (100%), rocuronium (98%) and multimodal antiemetic prophylaxis (99%). Lidocaine perfusion was used in 169 (87%) surgi-

cal procedures and continued until departure from the recovery room. Sugammadex had to be used in 52 (27%) procedures.

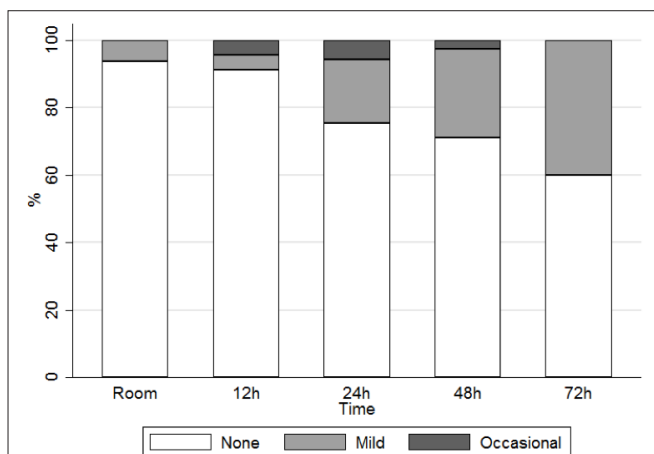
Anaesthetic complications occurred in 32 (16.5%) procedures. Twelve (6.3%) patients suffered delayed recovery due to hypothermia (n=7) or excessive sedation or curarisation (n=5). Ten (5.2%) patients had mild hypothermia at the end of the procedure. Other anaesthetic complications were 3 difficult intubations, 4 difficult i.v. accesses and 10 mild haemodynamic instabilities during the laparoscopic phase, requiring low-dose vasopressor treatment.

In the recovery room, moderate to severe pain was documented after 31 (16%) procedures, requiring >8 mg of morphine i.v. and with median doses of 13.7 mg (IQR 8.2–19.2). Median postoperative pain scores were 1 (IQR 0–4) and 3 (IQR 0–4) at 12 h and 0 (IQR 0–2) and 0 (IQR 0–3) at 72 h at rest and mobilisation, respectively (Figure 2). Symptoms of PONV were present in 6.1% of patients in the recovery room and in 40% of the 25 patients who were still in the hospital at 72 h (Figure 3).

No accidental exposure to chemotherapy occurred during the study period. Entry to the OR during the vaporisation phase was necessary <10 times, principally for anaesthetic pump dysfunction.



**Figure 2. Pain scores at rest and during mobilisation.** Evolution of pain scores over time after a PIPAC procedure, at rest and during mobilisation at different time points postoperatively  
VAS: visual analogue scale; S.E.M.: standard error of the mean; Room: recovery room



**Figure 3. Postoperative nausea and vomiting (PONV).** PONV after PIPAC at different time points  
Room: recovery room; PIPAC: pressurised intraperitoneal aerosol chemotherapy

No. of patients	87
Median age, years (IQR)	63 (55–70)
<b>Sex</b>	
Male	25 (27.8%)
Female	65 (72.2%)
Median BMI, kg m <sup>-2</sup> (IQR)	23.7 (21.2–26.8)
<b>ASA</b>	
II	57 (65.5%)
III	30 (34.4%)
<b>Aetiology of cancer</b>	
Ovarian	39 (44.8%)
Colorectal	29 (33.3%)
Gastric	8 (9.2%)
Mesothelioma	4 (4.6%)
Other	7 (8.1%)
Median no. of PIPAC procedures (range)	2 (1–7)
Median length of stay, days (IQR, range)	2 (2–3, 1–20)
IQR: interquartile range; BMI: body mass index; ASA: American Society of Anesthesiologists; PIPAC: pressurised intraperitoneal aerosol chemotherapy	



## Discussion

To the best of our knowledge, this is the first study to analyse the anaesthetic management and complications of patients undergoing PIPAC treatment. This surgical technique is special because the safety drug protocol requires the remote administration of intraperitoneal chemotherapy, limiting access to the patient. By using a dedicated anaesthetic protocol, anaesthesia for PIPAC ensured the safety of patients and health-care staff, and anaesthetic outcomes were similar to those of comparable procedures.

Pressurised intraperitoneal aerosol chemotherapy is a very new type of treatment, and evidence is so far limited. A first, nine-centre, international survey involved 832 procedures on 349 patients and evaluated the different aspects of PIPAC treatment with respect to surgical methodology. The study demonstrated that the procedures were performed the same way, probably explained by the standardised procedure and the limited number of expert centres (23). A systematic review on PIPAC, published in 2017 by Grass et al. (24), demonstrated that the procedure was safe and well tolerated. Histological response rates for therapy-resistant carcinomatosis of ovarian, colorectal and gastric origins were promising. Furthermore, our group's evaluation of QoL after PIPAC therapy demonstrated no negative impact of the treatment (25).

It has been shown that the safe implementation of PIPAC was possible from the surgical point of view—even with no learning curve—when the existing recommendations and protocols were followed (20). The requirement to be outside the OR and to apply anaesthesia far from the patient is a challenging scenario, but one which has been described previously, for example, in paediatrics with sedation for multiple sessions of radiotherapy (26-28). For the PIPAC procedure, anaesthesia must be given in a potentially toxic environment involving cytotoxic drugs. Although no emanations of cytotoxic agents were detected during experimental procedures and no air contamination was detectable at the surgeon's and anaesthesiologist's workstations (29), strict protocols, a safety checklist and a dedicated team are mandatory for the safe execution of this procedure, including following recommendations on the manipulation of cytotoxic drugs, as for HIPEC procedures (30).

Adherence to the anaesthetic protocol described above was high, despite the staff turnover inherent in a teaching institution. However, a senior anaesthesiologist and referent nurse anaesthetist were available on site, in the event of a problem, and the anaesthetic protocol and safety checklist were available on the department's intranet. This underscores the importance of homogenous pathways in maintaining standardisation regardless of staffing changes.

The overall severity of surgical complications was mild and has already been described by our group. We recorded no micro-pump injector disconnections or accidental vaporisation into the OR air during our series.

By using the recommended protocol, not one major anaesthetic complication was observed in 193 procedures. Hypothermia occurred mainly at the beginning of the study due to the initial technical problems with the laparoscopic-gas heater and/or late positioning of the forced air system and late prevention of hypothermia during anaesthetic induction and installation. However, peripheral venous access was challenging as most patients had few accessible veins due to multiple lines of upfront systemic chemotherapy. Other minor anaesthetic problems, such as haemodynamic instability, difficult intubation and delayed recovery due to excess sedation or curarisation, are inherent to all anaesthetic procedures in a teaching hospital and are not related to PIPAC procedures in particular.

Lidocaine i.v. was added to optimise pain management, but this occurred after the start of our study programme, thus explaining the 87% adherence rate. Pain scores were low thanks to a multimodal analgesic approach based on paracetamol and nonsteroidal anti-inflammatory drugs, and they were similar to those patients undergoing laparoscopic cholecystectomy (31). Only 26 (13.6%) procedures resulted in patients requiring morphine i.v. in the recovery room. With regard to the 40% of patients presenting with PONV at 72 h, only complicated and very frail patients had a hospital length of stay that long, thus explaining this high incidence of PONV.

## Conclusion

The anaesthetic management of patients undergoing PIPAC procedures can be performed safely by following the recommendations within a standardised pathway. Subtle adaptations of standard protocols are necessary to adjust to the requirements of the safety protocol, which includes remote administration. Despite this, the anaesthetic management and clinical outcomes of this procedure were comparable with operations of similar invasiveness and duration, such as laparoscopic cholecystectomy.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Lausanne University Hospital's Institutional Review Board - Pr. Patrick Francioli (2016-00274).

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.



**Author Contributions:** Concept – M.H.; Design – A.R., M.H., C.B.; Supervision – A.R., M.H., F.G., N.D., C.B.; Resources – N.D., C.B.; Materials – A.R., B.P.; Data Collection and/or Processing – A.R., B.P., F.G.; Analysis and/or Interpretation – A.R., B.P., F.G.; Literature Search – A.R.; Writing Manuscript – A.R.; Critical Review – A.R., M.H., F.G., B.P., N.D., C.B.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declared that this study has received no financial support.

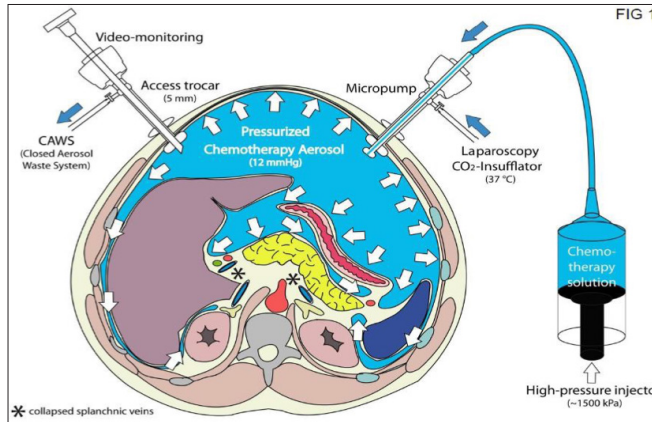
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## Online Appendix 1

Recommendations for the anaesthetic management of pressurized intraperitoneal aerosol chemotherapy (PIPAC)



### Preoperative assessment

- Preoperative anaesthetic consultation
- Evaluate associated comorbidities, nutritional status, cardiac, respiratory, renal, hepatic and metabolic functions
- Lab: CBC, Na<sup>+</sup>, K<sup>+</sup>, creatinine, urea, fibrinogen, TP, PTT, liver tests, albumin
- Know the different neoadjuvant treatments and their side effects (haematological and renal toxicity)
- Transfer to room unless a medical or surgical indication for continuing care

### Admission, layout and positioning in OR

- Surgical safety checklist (WHO)
- Supine position with legs apart resting on straight pads
- Left arm is positioned along the body, and right arm is in abduction at 90° for venous access
- Infusion stand to the right and Bair Hugger™ to the left of the patient
- Check laminar flow is “on”

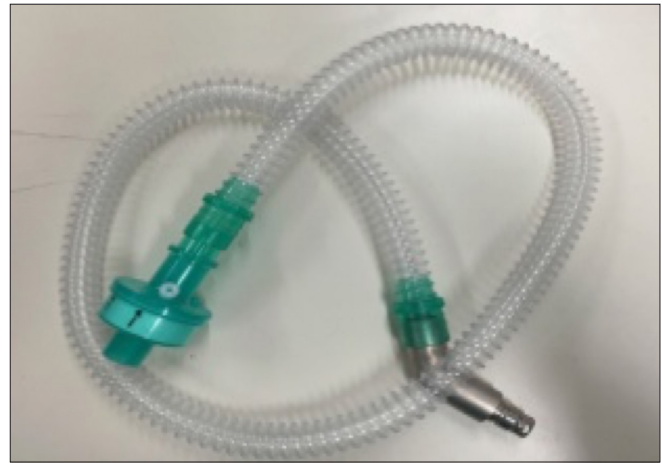


### Drugs to prepare

- Propofol 1% syringe and continuous perfusion, fentanyl, rocuronium, succinylcholine and MgSO<sub>4</sub>
- Prophylactic antibiotic
- If no contraindication, Xylocaine® IV, bolus at induction 1.5 mg/kg, then 2 mg/kg/h
- Ephedrine, Neo-Syneprine, atropine
- DHBP, dexamethasone and ondansetron

### Equipment

- ECG, BP, saturation, temperature, BIS, neuromuscular response with a hand accelerometer
- 2 IV lines on the right arm
- Orogastric tube to remove at the end of the procedure
- A forced air system (Bair Hugger™) on the upper body
- Connection for a closed aerosol waste system through two sequential microparticle filters into the anaesthetic air waste system
- High filtration face mask (FFP3), surgical gown, double nitrile gloves and protective glasses



### Induction and maintenance of anaesthesia

- Total IV anaesthesia
- Curarisation with rocuronium in bolus or continuous perfusion (0.3–0.6 mg/kg/h) with a target post-tetanic count (PTC) of between 5 and 8 to 10
- Fentanyl or sufentanil
- Antibiotics: cefuroxime (Zinacef®) 1.5 g IV (if allergic, refer to local protocol for prophylactic antibiotherapy)
- Magnesium sulphate 40 mg/kg
- PONV prevention: -at induction: DHBP 1 mg IV, Mephameson® 8 mg IV
- at the end of the procedure: Ondansetron 8 mg IV

### Cytostatics

- The surgeon estimates his operating time to coordinate the preparation and delivery of products by the pharmacy, usually at the beginning of the intervention



- Anaesthetists phone the pharmacy and the carrier to deliver the specific products

### Special precautions during the PIPAC phase

- Protection with surgical gown, non-porous nitrile gloves, 3M mask with filter and eye protection (protective visor)
- Handling of cytostatics with non-porous nitrile gloves and eye protection
- Elimination of cytostatic infusions and all material that has been in contact with them have to be binned in special containers (green)
- Elimination of the gas and cytostatic products of the pneumoperitoneum by connecting the closed aerosol waste system through two sequential microparticle filters into the anaesthetic air waste system
- Negative pressure in operating room throughout the PIPAC phase, maximum staff protection



### Anaesthesia checklist before vaporisation

Before leaving the room, make sure that:

- Operational safety checklist run-through by surgeons
- Positioning
- Ventilation screens, haemodynamics and automated accelerometer visible from outside OR
- Propofol, rocuronium and infusions in sufficient quantity for at least 40 min
- Deep curarisation ensured by rocuronium
- Analgesia
- Safe connection of the evacuation of gases

Medical and nursing personnel withdraw from the OR during chemotherapy vaporisation, and entry into the operating room must be avoided unless absolutely necessary.



### End of procedure and waking

- Paracetamol 1 g IV, ondansetron 8 mg IV
- Standard criteria for awakening and extubation
- If TOF 0/4 and PTC = 0: wait
- If TOF 0/4 and PTC > 1: sugammadex 4 mg/kg
- If TOF 1–3/4 or 4/4 and T4/T1 < 40%: sugammadex 2 mg/kg
- If TOF 4/4 and T4/T1 > 40%: neostigmine 40 µg/kg (+Robinul®) or sugammadex 1 mg/kg

### Cleaning and storage of the OR

- All disposable equipment is put in special green containers (Bair Hugger™, gastric tube, ECG electrodes, BIS, ...)
- Infusions, drugs, syringes in yellow containers
- Do not change the ventilation circuit, however; discard the disposable gas suction system in the green container.
- Caution: Do not discard the metallic connection!!!

### Recovery room and post-op

- Treatment of nausea:
  - Ondansetron 3 x 4 mg/day of office for 2–4 days
  - Mephamesone 4 mg 2 x/day in R
  - If persistent nausea despite the above treatment, consider Ivemend® = fosaprepitant 150 mg, refrigerate. To administer a single dose of 150 mg IV daily in combination with ondansetron and mephamesone 4–12 mg/day
- Antalgics:
  - Paracetamol po 4 x 1 g/day
  - Morphine IV in the recovery room up to 0.1–0.2 mg/kg, then sc
  - Lidocaine IV to continue at 2 mg/kg/h until exit of recovery room
  - Ibuprofen 3x 400 mg/day in R
  - Minalgine® IV 4 x 500 mg/day
- Transfer to the surgical department as soon as the transfer criteria have been fulfilled and after the visit of the anaesthesiologist doctor in charge

## Online Appendix 2

### OPERATIONAL SECURITY CHECK-LIST

#### PIPAC : Pressurized IntraPeritoneal Aerosol Chemotherapy

##### 1. Before starting the procedure = **Team time-out** :

- Patient's name OK ?**
- Planned procedure OK ?
- Chemotherapy drugs** available in the operating room ? Check for the label : patient, drug and dosage ?
- Safety material available ?
- All **team members** wearing glasses, gloves and protecting clothes as needed ?
- Special waste containers present in OR ?
- Protective sheet on the floor under the injector ?
- Laminar air flow activated in the operating room (OR) ?

##### 2. Check-list before application :

- Trocars tightly fixed** to the abdominal wall
- Sealed pneumoperitoneum** with 12 mm Hg CO<sub>2</sub> and no leak ?
- Closed Aerosol Waste System (**CAWS**) connected to the camera trocar. Closed clamp? Port valve closed ? Microparticule filter installed ? Connected to wall outlet ?
- Video camera inserted in trocar, fixed to the Octopus stand ?
- CO<sub>2</sub> tube adapted to 12 mm trocar (**insufflation port open**) ?
  
- Peritoneal Carcinosis Index (**PCI**) documented ?
- Ascites** volume documented ? Cytology ?
- Diagnostic peritoneal **biopsies** sampled in different areas ?
- Local peritonectomy performed ?
- Samples for research and studies obtained ? documented and labeled ?  
- No, not planned
- Micropump inserted in the 12 mm trocart port ? Free-floating and no contact with bowel loops?
- Cover sheet fixed to the micropump ? **System flushed** ?
  
- Syringe(s) with chemotherapy placed into the high-pressure injector ?
- Remaining air (dead space) removed from the syringe(s) ?

- High pressure line connected to the syringe(s) and fixed to the cover sheet ?
- Set up the injector : Syringe(s) **volume**, pressure max. 20 bars, flow 30 ml/min ?
  
- ePIPAC ? If yes :
  - Electrode positioned correctly ? Within the camera field (visible) ?
  - Generator **not** activated yet ?!!
  
- Screens and devices checked-up for remote monitoring ?
- All team members leave the operating room !**
- Remote-controlled application of chemotherapy product.
- ePIPAC : please activate the generator at the end of administration of cytostatics !
- Wait **30 minutes** after end of chemotherapy administration ?

### 3. Uninstalling and ending the procedure:

- Max 2 people in the OR: High filtration mask and sterile reinforced protective gown.
- ePIPAC : remove electrode !
- Stop CO<sub>2</sub> insufflator.** Close trocar port and disconnect tubing.
- Video camera oriented laterally in order to avoid bowel suction into the trocar port.
- Activate CAWS system (open port and valve), proceed to **closed exsufflation** of the toxic aerosol in closed circuit.
- Do not use standard suction devices !
- Close trocar port in order to avoid bowel suction into it (active suction !)
- Removal of all trocars with « en bloc » technique, thrown away in labeled waste container.
- All disposable material eliminated into labeled chemotherapy waste container.
  
- Prospective documentation in a dedicated database ?
- For study patients, make the Case Report Forms (CRFs) complete.

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Nom

Signature