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### **1. Assisting the surgeon in achieving sufficient laparoscopic workspace at the lowest intra abdominal pressure possible.**

The laparoscopic surgeon requires sufficient workspace. More than 4 liter is always sufficient, less than 2 liter is always a problem. The laparoscopic field should be also quiet and not move. The diaphragm moves down during inspiration, active by muscle contraction and passive by the ventilator. As long as this is regular the surgeon can handle this movement. When the diaphragm contracts during the ventilator expiration an extra inspiration gives irregular movements. This is not dramatic yet, but most ventilator modes, except pressure support, cannot handle this. When the ventilator tries to force an inspiration during the following spontaneous expiration the abdominal muscles comes in action. A forceful contraction tries to prevent the ventilator blowing in while the patient wants to exhale. This is the dramatic moment of a patient pressing against the anaesthesia ventilator and increasing the abdominal pressure to very high pressures. The ventilator alarm and the insufflator alarm will sound. The abdominal compliance gets now very small and thanks to the one-way valve of the insufflator the abdominal volume drops slower in according to the CO<sub>2</sub> leaks. Deep anaesthesia with very high dose opioids can block the respiratory centre and prevent this action but it is easier and better to provide deep NMB or well adapted pressure support ventilation.

Abdominal compliance is linear in humans allowing the characterization of each abdomen with two parameters: Elastance E or its reciprocal the Compliance C and the pressure at zero volume PV<sub>0</sub>.<sup>i</sup> Prediction of abdominal compliance remains difficult. Nevertheless some factors like no gravity, first laparoscopy or no weight reduction in young and sport active patients suggest possible small laparoscopic workspace and higher airway pressures during ventilation. Nevertheless the inter-individual variation in abdominal compliance is that large making the measurement in each individual patient necessary at the start of the laparoscopy. The effect of muscle relaxation on the achieved extra workspace varies also. Sufficient workspace at the lowest airway pressures requires that every patient should be maximal relaxed.

Verify that muscle relaxation is sufficient deep at a TOF 0 and a PTC < 4 measured at the thumb. Never rely totally on the TOF measurement only as the diaphragm is the muscle with the largest resistance against curarisation and the technology to measure TOF might fail. Verify with you hands the finger movements and exclude direct muscle stimulation. At a PTC above 4 abdominal muscles have already enough strength to contract actively and reduce the abdominal compliance dramatically when the patient breathes against the ventilator.

Measure during the first inflation the starting pressure and the pressure at maximum volume. This gives you already a rough estimation of the E and PV<sub>0</sub>.

Correct measurement is possible when the first trocar is positioned. Measure three pressure volume points at around 1 liter difference. Stop each time the inflator and note the inflated volume as well as the lowest abdominal pressure indicating the end expiratory phase. Draw a linear line through 3 points and calculate PV<sub>0</sub> as the crossing with the Y-axis and E as the angle of the line.

Calculate the intra abdominal pressure needed to reach an abdominal volume of 4 liter. Set the inflator to this level or slightly higher. If more than 15 mmHg is needed verify that ventilation is not impaired and keep maximum muscle relaxation till the end. It increases the volume with 600 ml on average. This is the group of patients that might require Sugammadex for decurarisation.

Use the beach chair position, reversed trendelenburg and leg flexion at the hips, to improve the volume with 700 ml on average for the same pressure.<sup>ii</sup>

After the induction dose subsequent doses should be give in time and before surgeon is disturbed by insufficient place or no place when the patient breathes against the ventilator. The surgeon complaining of no place is always right, as can be the anesthesiologist too, in giving total muscle relaxation. Continuous infusion of rocuronium with TOF monitoring facilitates continuous maximum relaxation. If you give only bolus you might be too late. We start a rate of 50 mg/h and increase or decrease according to TOF and PTC keeping TOF at zero and PTC < 4. If the surgical workspace is very small, IAP is also increased to maximum 20 mmHg. If still not enough space we give an abdominal recruitment maneuver using our ARM system for a short moment if hemodynamic stable. Maximum relaxation is kept till the end of the pneumoperitoneum in all patients. At 1 MAC inhalation has no relaxing effect. High dose Remifentanyl has not any relaxing effect, it only prevents spontaneous breathing or movements if not deep relaxed. Such a deep anaesthesia with Remifentanyl creates very low BIS levels and should be avoided today. In this opioid free protocol no sufentanyl or remifentanil is used anymore.

## **2. Assisting the surgeon during the surgical construction of the gastric pouch**

Emptying the stomach immediately after anaesthesia induction and correct positioning of the gastric tube are two important requirements for every bariatric surgeon. Never insert a gastric tube deeper if resistance is felt, certainly in revision procedures. Make notice of the depth and learn to see the tube tip and its movements on the laparoscopic view. A 34 F (gastric bypass) or a 38 F (gastric sleeve) is the most common sizes used. A small 24 F size exists also and is not suitable for sizing but can be useful in revision surgery when obstruction limits a larger size. The larger the tubes the stiffer and more dangerous they are when not properly handled. They allow a correct surgical sizing of the pouch, a better draining of fluid and a faster filling during the leak test.

First deflate the stomach, never suction on the large tubes and keep the tube always open and in drainage (certainly when moving it up and down). If you want to suction, like for controlling for intraluminal bleeding, you should cut the tube to a length of 40 cm (marker needed) and enter with a small suction catheter of 40 cm length to have safe "Sump drain" suction.

After the first staple line, introduce the tube slowly to the base of the gastric pouch created when the next stapler is closed. If you feel a higher resistance notify your surgeon. Ask to move the tube 2 cm up and down to verify that the stapler is not put on the tube and that the size is correct. When the surgeon dissects under the stomach and flexes the pouch upwards the gastric tube might need to be withdrawn less than one cm. Advance one centimetre if needed to keep traction on the pouch while the surgeon places the third stapler. When the pouch is created redrawn the tube again in the oesophagus. Look always at the laparoscopic screen when asked to move and verify the position of the tip.

Besides positioning the gastric tube it is also important to help improving the tissue compression and stapling quality by adapting the anaesthesia. During stapling the tissue should be without any oedema and not distended by dilated blood vessels. Therefore the blood pressure should be below 100-mmHg Sap and all measures given to avoid oedema. First keep the patient intravenous dry, only 100 ml/h and give extra fluids only if pulse pressure variation shows hypovolemia, then avoid all drugs that trigger inflammation like opioids and add drugs that block inflammation directly or indirectly. Direct anti-inflammatory drugs are corticoids, NSAID's; indirect drugs are sympatholytic blockers and painkillers. All measures together allow keeping the wall dry and thin without oedema making the compression more effective. Waiting before firing the staple remains important but will be probably more effective.

## **3. Assisting the surgeon in performing the leak test at the end of the procedure.**

At the end of the operation the gastric tube is re-inserted under laparoscopic view and stopped 2 cm below the gastro jejunostomy. The surgeon closes the descending jejunum. Inject 150 ml methylene blue water (make it strong enough: add 4 amp Methylene blue for 1 liter water) as fast as possible to distend the gastric pouch using a 150 cc syringe for gastric lavage. Close the tube while refilling the syringe with air and inject the 150 ml air for further distension and evaluation of leakage. Adapt your injection speed according to the space left by the surgeon (A very close occlusion to the gastro jejunostomy and testing after placing manual stiches requires a slower injection speed.) The tube is slowly withdrawn while opened to the air, to evacuate the methylene blue fluid. A good night stitch and if needed some extra stiches are placed on the distending places where some air or blue fluid escaped.

Under this extreme volume stretch more leaks will be seen. But you can be sure that no leak will be missed post operative. Besides the loading test is it also important to look to the perfusion colour, while blood pressure is increased, to avoid late leaks due to ischemia. (See next) The tube is withdrawn in the oesophagus and kept draining the fluids and air. If you aspirate the oral cavity during the leak test, you can avoid having a patient with a blue face post operative. If you want to aspirate the gastric tube never suction directly on the large tube but insert a smaller (18 F) aspiration tube inside the gastric lavage tube (Sump principle) and control for intraluminal bleeding.

## **4. Methods used to prevent postoperative bleeding and revision surgery.**

The quality of laparoscopic staples has improved a lot in the last decennia. Appropriate tissue compression and the choice of a staple height ranging from 0,75 to 2,3 mm have generated more leak-proof and haemostatic staple lines. However post operative bleeding and leak remains possible and therefore one has to do everything to bring this complication to zero. The surgeon dissects the blood vessels around the purse-string gastric pouch what avoid stapling of large vessels. Staples keep the small arterial blood vessels still open by preventing spontaneous retraction and closure. Therefore some arterial blood vessels might start to bleed late post operatively when systolic pressure increases due to pain and waking up. Therefore the anaesthesiologist increases the arterial pressure at the end of the operation to visualize and correct possible bleeding by haemostatic clips. Coagulation of the staple lines is never done as this increases the risk of ischemia and leak.

At a SAP below 90 mmHg all staples lines are totally white without any bleeding spot. This might be nice for the surgeon to operate in a blood free workspace but gives also no information on perfusion adequacy.

At a SAP of 110 mmHg staples lines are oozing and get a red appearance.

At a SAP of 140 mmHg bleeding spots that otherwise might have missed could be visualized. <sup>iii</sup>

The surgeon can easily put some extra manual stitches or a single clip on the blood vessel, better than to coagulate the staple line and risking ischemia and leaks.

This is also the good moment to verify that all enteral tissue is well perfused and has a nice red colour in order to prevent ischemia and late leak. This is more important in revision surgery.

An other option previously suggested was to keep the blood pressure low post operative. This requires post operative sedation and intensive care therapy and might impair wound perfusion and wound healing. Our option is therefore easier and safer but requires the surgeon to wait till blood pressure increases.

The anaesthesiologist can use different methods to achieve this blood pressure rise. Traditional extra intravenous fluid is given, anaesthesia depth is reduced and last ephedrine and/or phenylephrine is given. Today we first allow end tidal CO<sub>2</sub> to rise what increases cardiac output and then to give ephedrine and/or phenylephrine according to heart rate, while fluids are given only when signs of hypovolemia are visible.

By applying these methods the post operative bleeding incidence in RNY gastric bypass dropped over 10 years from 3 % to 1,1 % and lower in the redo surgery. The number of revisions for bleeding after surgery dropped from 0,95 % to 0,1 % in primary RNY gastric bypass and to 0 % in the redo surgery.

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<sup>i</sup> Mulier J, Dillemans B, Crombach M, Missant C, Sels A. On the abdominal pressure volume relationship IS PUB 2009;21:1

<sup>ii</sup> Mulier JP, Dillemans B, Van Cauwenberge S. Impact of the patient's body position on the intra-abdominal workspace during laparoscopic surgery. Surg Endosc. 2010;24:1398-402.

<sup>iii</sup> Mulier J, Dillemans B, Vandrogenbroek G, Akin F. The effect of systolic arterial blood pressure on bleeding of the gastric stapling during laparoscopic gastric bypass surgery. Obes Surg 2007;17:A1051