Haemodynamic monitoring during laparoscopic liver resection

Hemodinamski nadzor med laparoskopsko jetrno resekcijo

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Abstract

Introduction. *Minimally invasive surgery has been gaining popularity because of its clear advantages over open surgery, which include: lesser surgical trauma, shorter hospital stay, better cosmetical effect and improved patient satisfaction. Greater experience gained in both laparoscopy and liver surgery has made laparoscopy a technically feasible and safe treatment option for some liver resections.*

Patients and Methods. *Haemodynamic monitoring during minimally invasive surgery: the term "minimally invasive surgery" does not imply that this surgical technique carries less perioperative risk for the patient. Perioperative hazards of laparoscopic liver resection are mostly the same as in open liver surgery. These include: massive bleeding, haemodynamic instability due to compression of the inferior vena cava and anaphylactic reaction in patients with echinococcus disease. In addition, there may be haemodynamic effects of pneumoperitoneum, such as decreased preload, increased systemic vascular resistance, decreased cardiac output, and increased risk for* CO_2 *embolism.*

The greatest benefits offered by the minimally invasive approach are the patient's comfort and safety. From the standpoint of the anaesthesiologist this goal is best met by perioperative monitoring, which allows for timely detection of potentially dangerous events and for appropriate action.

Results. *Since January 1997, 31 patients with liver disease have been treated laparoscopicaly in this institution. In three cases, occlusion of the hepatoduodenal ligament was used to control the bleeding. In one patient – the only one who needed blood transfusion - conversion to open surgery was required because of bleeding.*

Conclusion. In view of the current possibilities of monitoring, using minimally invasive approach in LLR is not judicious. Dynamic perioperative changes dictate beat-to beat systemic arterial pressure measurement and arterial catheter insertion. A wide-bore venous line and a central venous catheter have to be used for adequate fluid management and eventual blood transfusion. In the future, noninvasive methods of accurate perioperative haemodynamic assessement may prove useful in laparoscopic liver resections. These include: oesophageal Doppler CO monitoring and assessment of cardiac output from systemic arterial pressure by the pressure recording analytical method (PRAM).
Thanks to the required experience gained with both laparoscopy and liver surgery, the minimally invasive approach has become a technically feasible and safe technique in some liver resections. Perioperative hazards of laparoscopic liver surgery are mostly the same as in open liver surgery; in addition, haemodynamic effects of pneumoperitoneum are likely to occur. Considering the present monitoring possibilities, it is not judicious to use the minimally invasive approach in laparoscopic liver resections. In the future, noninvasive methods of perioperative accurate haemodynamic assessement during laparoscopic liver resection may prove useful.

Key words. *Laparoscopic surgery, liver resection, haemodinamic monitoring.*

Izvleček

Uvod. V zadnjih letih so minimalno invazivni postopki v kirurgiji vse bolj priljubljeni. V primerjavi s klasičnimi operacijami je kirurška poškodba manjša, bolniki ostanejo v bolnišnici manj časa, kozmetični videz je manj prizadet in bolniki so bolj zadovoljni. Zaradi novih znanj in izkušenj v jetrni kirurgiji in laparoskopskih tehnikah je nekatere jetrne resekcije možno varno narediti na laparoskopski način.
Bolniki in metode. Nadzor obtočil med minimalno invazivnimi operacijami: pojem «minimalno invazivna kirurgija« ne vključuje tudi minimalnega tveganja za bolnika med posegom. Tveganje med laparoskopsko jetrno resekcijo (LJR) je enako kot med klasičnim posegom: obsežna krvavitev, hemodinamska nestabilnost in anafilaktična reakcija pri bolnikih z ehinokoknimi spremembami v jetrih. Tem zapletom se pridružijo še hemodinamski učinki pnevmoperitoneja: zmanjšan pritok krvi v srce, povečan upor ožilja, zmanjšan minutni volumen srca (MV) in nevarnost embolije s CO_2. S stališča anesteziologa zagotovimo bolniku največjo varnost z nadzorom, ki omogoča hitro zaznavo in pravočasno ukrepanje ob zapletih.
Rezultati. Od januarja 1997 smo laparoskopsko operirali 31 bolnikov z boleznijo jeter. Pri treh bolnikih smo zaradi kontrole hemostaze uporabili zaporo hepatoduodenalnega ligamenta. Pri enemu bolniku – ta je bil edini, ki je potreboval transfuzijo krvi – smo morali preklopiti v odprt kirurški poseg.
Zaključek. Glede na trenutne možnosti minimalno invazivni nadzor pri LJR ni priporočljiv. Hitre spremembe hemodinamike terjajo invazivno merjenje krvnega tlaka in i.v. port s širokim premerom za zdravljenje s tekočinami in transfuzijo krvnih pripravkov. Trenutno so še v razvoju novi načini hemodinamskega nadzora, npr. ezofagealni dopplerski nadzor MV in ocena MV z računalniško analizo sistemskega krvnega tlaka. S kombinacijo izkušenj, pridobljenih z laparoskopsko tehniko in z jetrnimi resekcijami, je postala LJR tehnično izvedljiv in varen poseg. Tveganje med operacijo združuje nevarnosti klasične operacije in posledic pnevmoperitoneja. Glede na današnje možnosti hemodinamskega nadzora se pri LJR ni priporočljivo zanašati na minimalno invazivni pristop, ki pa bo verjetno dosegljiv v prihodnosti.

Ključne besede. Laparoskopska kirurgija, resekcija jeter, hemodinamski nadzor.

Minimally invasive surgery has been gaining popularity because of clear advantages it offers over open surgery. These include: lesser surgical trauma, shorter hospital stay, better cosmetical effect and improved patient satisfaction. Greater experience gained in both laparoscopy and liver surgery has made laparoscopy a technically feasible and safe approach in some liver resections (1-2).

Some authors advocate the use of laparoscopic access in benign tumors and hydatid cysts (3).

A recent analysis comparing 30 laparoscopic liver resections (LLR) with 30 open liver resections showed that minor LLR of the anterior segments carried the same mortality and morbidity rates as open surgery, yet that it had the advantage of reducing blood loss and the time of postoperative hospital stay (4,5).

Since January 1997, 31 patients with liver disease have been treated laparoscopically in this institution. In three cases, occlusion of the hepatoduodenal ligament was used to control bleeding. In one patient – the only patient who needed blood transfusion – conversion to open surgery was required because of bleeding.

The laparoscopic access was also used in the treatment of malignancies (6). Some of the benefits of minimally invasive surgery have been linked to the decreased metabolic and immune responses involved. LLR results in a diminished stress response as compared with that of open resection, which translates into better preservation of immune function. This finding may well have a beneficial effect on infection and tumor growth (7).

Recent animal studies and human case reports have confirmed the feasibility of laparoscopic living donor hepatectomy. Once the safety and feasibility of the procedure have been shown in larger series, laparoscopic donor left lobectomy could become a new option for paediatric living donor liver transplantation (8-11).

Haemodynamic monitoring during minimally invasive surgery

The term "minimally invasive" does not imply that this type of operation carries less perioperative risk for the patient. The greatest benefits derived from this treatment option are the patient's comfort and safety. From the standpoint of the anaesthesiologist this goal is best met by perioperative monitoring, which enables him/her to detect potentially dangerous events in time and to act appropriately.

Perioperative hazards of LLR are mostly the same as those encountered in open liver surgery, i.e.: massive bleeding, haemodynamic instability due to compression of the inferior vena cava and anaphylactic reaction in patients with echinococcus disease. In addition, haemodynamic effects of pneumoperitoneum may occur, such as a decreased preload, increased systemic vascular resistance (SVR), decreased cardiac output (CO), and increased risk for CO_2 embolism.

Additive effects of pneumoperitoneum creation and portal triad clamping (PTC) on haemodynamics

The well-known haemodynamic changes occurring during pneumoperitoneum creation include: increase in mean arterial pressure (MAP) and SVR, and decrease in CO. Similar haemodynamic changes are characteristic of PTC which is used during liver resections to reduce bleeding. Some authors found these changes similar to those of chronic cardiac failure (12). Potentially serious haemodynamic changes may therefore occur with LLR.

In an experiment on pigs this setting caused severe haemodynamic deterioration. The authors concluded that PTC should be considered only as a last resort for the control of bleeding during laparoscopic liver surgery (13).

The clinical significance of haemodynamic changes caused by PTC and pneumoperitoneum was studied in ten patients without cardiocirculatory disease. Haemodynamic variables were measured using a pulmonary artery catheter and the thermodilution technique. In this small study, PTC and pneumoperitoneum caused only slight changes in MAP, SVR and CO compared to the porcine model. During PTC no difference in haemodynamic parameters was found between laparoscopy and open surgery groups, which may be attributed to inadequate statistical power of the study. However, the authors concluded that LLR with PTC was a feasible and safe treatment option in patients with normal cardiac function (14).

CO_2 embolism in laparoscopic liver resections

One of the potential complications of LLR is CO_2 gas embolism. Because of increased intra-abdominal pressure, CO_2 may embolise through severed blood vessels and liver parenchyma.

Two animal studies investigated the influence of CO_2 pneumoperitoneum on the incidence of embolism. It was hypothesised that elevated intrahepatic vascular pressures and decreased hepatic tissue blood flow prevented gas embolus formation during LLR under pneumoperitoneum. Intrahepatic vascular pressures and intrahepatic blood flow were measured in pigs with a varying CO_2 pneumoperitoneum. Gas embolus was determineed after hepatic incision by monitoring pulmonary arterial pressure (PAP), hepatic venous PCO_2 and systemic blood pressure, and by suprahepatic vena cava ultrasound. As the pneumoperitoneum increased from 0 to 15 mmHg, a significant increase in intrahepatic vascular pressures and a significant decrease in liver blood flow were noted. Hepatic incision produced no ultrasound evidence of gas embolus and no changes in PAP, systemic blood pressure, or hepatic venous PCO_2. The study suggested that the risk of significant embolus formation during LLR under conventional pneumoperitoneum is minimal (15).

In contrast to these promising results were the findings of another porcine study comparing risks of gas embolism during open hepatic resection and LLR. During surgery, the animals were monitored haemodynamically by an arterial line and Swan-Ganz catheter. Two-dimensional trans-oesophageal echocardiography (2D-TEE) was used to detect gas emboli with special attention being paid to the right atrium and ventricle. No air embolism was seen during open surgery, while during LLR, 2D-TEE revealed gas emboli in all animals. It was concluded that LLR done under CO2 pneumoperitoneum carried a high risk of gas embolism (16).

Haemodynamic monitoring during liver resections

Considering the present monitoring possibilities, we think that using the minimally invasive approach in LLR is not judicious. Dynamic perioperative changes dictate beat-to-beat systemic arterial pressure measurements and arterial catheter insertion. A wide-bore venous line and central venous catheter should be used for adequate fluid management and eventual blood transfusion.

Noninvasive methods of CO measurement

In the future, noninvasive methods of peri-operative accurate haemodynamic assessment may prove useful in LLR.

Oesophageal Doppler CO monitoring

Oesophageal Doppler can provide continuous online haemodynamic data, and allows for a rapid response to acute changes. It may therefore have a role in noninvasive haemodynamic monitoring during laparoscopic procedures

A preliminary study compared central venous pressure (CVP) monitoring with a noninvasive measure of cardiac preload (esophageal Doppler) during laparoscopic donor nephrectomy. Following the induction of general anaesthesia, a Doppler probe was inserted in the lower third of the oesophagus to measure the flow time corrected for heart rate (FTc), which is an index of preload. Lateral positioning and pneumoperitoneum significantly increased CVP from baseline while the FTc did not change. It was concluded that CVP was not an accurate guide for the administration of IV fluids during laparoscopic donor nephrectomy (17).

Assessment of CO from systemic arterial pressure – PRAM

Assessment of cardiac output from systemic arterial pressure measurements is a new method for cardiac output assessment, called pressure recording analytical method (PRAM). It was derived from the analysis of the arterial pressure-blood flow relationship.

The method was evaluated in a group of haemodynamically stable cardiac patients. The cardiac index was estimated simultaneously by the direct Fick method, thermodilution and PRAM applied to pressure signals recorded either invasively from an aortic catheter (PRAMa) or noninvasively at the finger (PRAMf) by photoplethysmography. Cardiac index values obtained by standard techniques were significantly correlated with those yielded by PRAM. PRAM may prove clinically useful for the beat-to-beat cardiac output monitoring (18).

Conclusion

Thanks to a more extensive experience gained in both laparoscopy and liver surgery, the minimally invasive technique has become a technically feasible and safe approach for some liver resections. Perioperative hazards of LLR are mostly the same as in open liver surgery, and include: massive bleeding, haemodynamic instability due to compression of the inferior vena cava and anaphylactic reaction in patients with echinococcus disease In addition, there may be haemodynamic effects of pneumoperitoneum, such as decreased preload, elevated SVR, decreased CO, and greater risk for CO2 embolism. The principle of “minimal operative invasiveness” has not significantly reduced the perioperative risk for a patient. From the standpoint of the anaesthesiologist the patient’s safety is best ensured by perioperative monitoring, which makes timely detection of potentially dangerous events and appropriate action possible. Considering the current possibilities of monitoring, we think that the use of minimally invasive approach in laparoscopic liver resections should be discouraged. In the future, noninvasive methods of perioperative accurate haemodynamic assessment during LLR may prove useful.

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