Anesthetic Management of Laparoscopic Surgery for Infants and Children

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[Abstract] The evolution of technology has made great advances in laparoscopic surgery. It can be said that most types of abdominal surgery in pediatrics are attempted under laparoscopy. The anesthesia management of laparoscopic surgery in infants and children has unique features and potential pitfalls. Anesthesiologists should be familiar with the varieties of physiological changes in laparoscopic surgery, mainly resulting from increased intra-abdominal pressure by insufflated CO₂, increased absorption of CO₂, and patient positioning. Anesthetic management depends on each patient’s clinical condition. Except for short diagnostic laparoscopy, patients are usually paralyzed with muscle relaxant and intubated. The cuffed endotracheal tube can be carefully used for effective positive pressure ventilation. Ventilatory strategy might be readjusted during pneumoperitonium. Anesthesiologists should also pay attention to intra-abdominal pressure because high pressure (>15 mmHg) will cause serious problems. Complications include difficulties in surgical techniques and problems related to pneumoperitoneum. The complication rate is known to largely depend on the surgeon’s skill and experience.

Key Words: Pediatric anesthesia, Laparoscopic surgery, Pneumoperitoneum

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Introduction

The evolution of technology, such as high-resolution video cameras presenting an enlarged picture on a monitor, has made great advances in laparoscopic surgery. The first laparoscopic cholecystectomy was reported in 1989. Since then, laparoscopic surgery has been tried with various kinds of abdominal surgery. In the 1990s, the indication of laparoscopic surgery was expanded to the pediatric population. Now it can be said that most types of surgery in pediatrics are attempted under

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Table 1  Age distribution of laparoscopic surgery recipients, Dept. of Pediatric Surgery, Saitama Medical University Hospital (1996–2005)

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1 month</td>
<td>16</td>
</tr>
<tr>
<td>1 month–1 y</td>
<td>150</td>
</tr>
<tr>
<td>1 y–7 y</td>
<td>455</td>
</tr>
<tr>
<td>7 y–18 y</td>
<td>476</td>
</tr>
<tr>
<td>&gt; 18 y</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>1,137</td>
</tr>
</tbody>
</table>

laparoscopy, even hepatoporoenterostomy for biliary atresia\(^1\). Now the length of the incision no longer indicates the magnitude of the surgery.

Although prospective randomized controlled studies comparing open and laparoscopic surgery are few, especially in children, laparoscopic surgery seems to have many advantages over open surgery. Generally, these advantages include less scarring, less pain, and early discharge. Laparoscopic surgery in infants and children has been shown to be feasible in terms of safety and performance\(^2\). Although not all laparoscopic procedures are superior to equivalent open procedures, the indication of laparoscopic surgery will be further expanded in the future.

The anesthesia management of laparoscopic surgery in infants and children has unique features and potential pitfalls. In this lecture, the author will briefly discuss the indication of laparoscopic surgery, physiological changes, and anesthesia management to safely accomplish anesthesia for laparoscopic surgery in infants and children.

### I  Indication of laparoscopic surgery in infants and children

In the department of pediatric surgery in Saitama Medical University, laparoscopic surgery for the pediatric population was started in the past decade. We now have more than 1,100 case experiences, at what is one of the largest pediatric laparoscopic surgical centers in Japan.

Our experiences are reviewed in Tables 1 and 2.

### II  Physiological changes during laparoscopic surgery

In laparoscopic surgery, pneumoperitoneum by insufflation of CO\(_2\) is created. The pneumoperitoneum with CO\(_2\) causes various physiological changes. Physiological changes in laparoscopic surgery mainly result from increased intra-abdominal pressure by insufflated CO\(_2\), increased absorption of CO\(_2\), and patient positioning. In recent years, several research projects have been conducted to clarify the effects of pneumoperitoneum on respiratory and cardiovascular systems in infants and children.
Respiratory effects:

Pneumoperitoneum shifts the diaphragm in the cephalad direction. When surgeon requests the Trendelenburg position, the diaphragm shifts further towards the cephalad and impairs effective movement. This causes reduction of FRC, which contributes to collapse of the small airway and facilitates intrapulmonary shunting. Patients tend to develop poor oxygenation during laparoscopy, especially patients with underlying pulmonary disease. The use of PEEP may counteract the effects of increased intra-abdominal pressure on respiratory mechanics.

Insufflated CO₂ is rapidly absorbed into blood. The absorption of CO₂ imposes an increased load on the respiratory system. If patient is on controlled ventilation and the ventilator setting is not changed in response to an increased CO₂ load, PaCO₂ would increase and respiratory acidosis will ensue. Acidosis, especially combined with volatile anesthetics, sensitizes the myocardium to catecholamine.

Generally, the risk of postoperative pulmonary complication is lower than equivalent open procedures. The respiratory effects of pneumoperitoneum usually resolve after CO₂ insufflation and rarely cause residual respiratory dysfunction. However, respiratory acidosis may be prolonged postoperatively in patients who have poor respiration or who have undergone an upper abdominal laparoscopic procedure. Residual anesthetics may cause delayed excretion of CO₂ dissolved in the body tissue, especially following a prolonged laparoscopic procedure.

Cardiovascular effects:

Increased intra-abdominal pressure, dissolved CO₂ and patient positioning result in significant cardiovascular changes. Cardiac output is reduced because of increased afterload and decreased venous return under high intra-abdominal pressure. Pulmonary vascular resistance is known to increase even if normocapnia is maintained. Abdominal distension by insufflated CO₂ occasionally causes bradycardia via the vagal reflex. Tachyarrhythmia is occasionally seen because of respiratory acidosis and increased catecholamine level. Patients who have intracardiac shunts or have single ventricle physiology are prone to significant physiological changes in pneumoperitoneum.

Others:

Since intracranial pressure tends to increase during laparoscopy, laparoscopic surgery is considered to be contraindicated for patients with “tight” intracranial physiology. Laparoscopic surgery is believed to be less invasive as compared to open surgery; however, stress hormone response is known to be similar to equivalent open surgery.

Ⅲ Anesthetic management

Anesthetic management depends on each patient’s clinical condition. The preanesthetic round includes routine chart review and lab screening tests if indicated. During the preanesthetic round, post-operative problems, especially nausea, vomiting and referred pain, should be discussed with the patient and guardians. Sedative premeds and/or parental presence may facilitate smooth anesthetic induction. In case of an emergency or with patients who have a full stomach, rapid sequence technique is preferred. Except for short diagnostic laparoscopy, patients are usually paralyzed with muscle relaxant and intubated. Routine atropine administration is not indicated, but it might be given if vagal reflex response to pneumoperi-
tioneum should be avoided. For laparoscopic surgery, cuffed endotracheal tube (ETT) can be selected. Cuffed ETTs are available over 3.0 mm ID, so one can be used for even small infants. The cuff pressure should be carefully monitored to avoid mucosal injury. An oro/naso-gastric tube should be put in place for decompressing the stomach and aiding the surgical view.

The maintenance of anesthesia is accomplished by either volatile or intravenous anesthetics. Nitrous oxide is not recommended for routine use because it may distend the intestine and obstruct the surgical view. Narcotics can be used with titration. Routine ASA standard monitoring is used for most cases. EtCO₂ monitor is useful for adjusting the ventilator setting. However there may be a large discrepancy between EtCO₂ and actual PaCO₂. In the case of a complicated patient, arterial line placement to draw blood for blood gas analysis and to monitor blood pressure may be considered. The ventilatory strategy might be readjusted during pneumoperitonium if the anesthesiologist wants to maintain normocapnia. Anesthesiologists should pay attention to intra-abdominal pressure because high pressure (> 15 mmHg) will cause serious problems. Fluid management depends on the patient’s hydration status. Sensible and insensible body fluid loss is believed to be lower than with open procedures, and fluid requirement is usually lower than expected. Because increased intra-abdominal pressure decreases renal blood flow, urine output is occasionally reduced during laparoscopy even though the patient is well-hydrated. During surgery, the surgeon might request that the bed be tilted. Before beginning, the patient must be well positioned.

At the end of a case, the peritoneum should be deflated completely; otherwise residual CO₂ in peritoneal cavity can impair spontaneous breathing and causes postoperative vomiting and referred shoulder pain. The patient’s stomach should be decompressed and antiemetics given. The patient is extubated as routine anesthesia emergence.

IV Complications

In most reports, the complication rate of laparoscopic surgery is slightly higher than the equivalent open procedure. Complications include difficulties in surgical techniques and problems related to pneumoperitoneum. The complication rate is known to largely depend on the surgeon’s skill and experience.

Complications related to pneumoperitoneum include subcutaneous emphysema, pneumothorax, pneumoperitoneum, and gas embolism. In children with congenital heart disease, paradoxical embolism would occasionally occur if a gas bubble entered systemic circulation through right to left shunt. The effects of hypercapnea and hypoventilation on respiratory and cardiovascular functions have been discussed before. Surgical complications include bowel perforation, solid organ injury, and great vessel injury. In severe cases, conversion to open surgery must be considered.

Chen reviewed 574 cases of pediatric laparoscopy. The overall complication rate was 2%. In 4 cases, significant hemorrhage occurred during surgery and was thus converted to open procedures. Complications related to pneumoperitoneum were not reported. Peters conducted a mailed survey in members of the American Academy of Pediatrics, Section on Urology, to clarify the complication rate of pediatric urological laparoscopy. Out of a total of 5,428 laparoscopic procedures reported,
complications were reported in 5.38%. Preperitoneal insufflation and subcutaneous emphysema were the most frequent complications. No deaths were reported. The strongest predictor of the laparo-
soscopic complication rate was the extent of the prac-
titioner’s experience. Appropriate supervised train-
ing of surgeons was emphasized to minimize com-
lications.

Summary

Laparoscopic surgery is useful and feasible in the pediatric population. Anesthesiologists should be familiar with physiological changes and potential problems associated with pneumoperitoneum.

References


小児腹腔鏡手術の麻酔管理

蔵谷紀文

埼玉医科大学麻醉学教室小児麻酔部門

高解像度のビデオ機器や手術機械の進歩により小児の腹腔鏡手術の適応は拡大している。腹腔鏡手術は同等の開腹手術に比して多くの利点が期待されている。手術中は気腹操作による腹腔内圧の上昇、吸収された二酸化炭素ガス、および術中体位の影響によりさまざまな生理的変化をきたす。麻酔は、特に小児の場合は、気管挿管による全身麻酔が望ましい。気腹中は特に呼吸状態に注意する。小児用のカフ付き気管チューブは利点が大きいが、小児ではカフ圧をモニターするなどの注意が必要である。術後疼痛は軽度とはいいえない場合もある。熟練した外科医の方が合併症発生率が低くなることが知られている。

Key Words: 小児麻酔、腹腔鏡手術、気腹

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