ABSTRACT. **Objectives.** Video-surgery in neonates is recent. Data on the respiratory, hemodynamic, and thermic effects during the first month of life are still sparse. This study aimed to evaluate the tolerance of video-surgery in neonates and to determine the risk factors of per-operative complications.

**Methods.** From 1994 to 2004, 49 neonates (mean age: 11 days; weight: 3285 g) underwent 50 video-surgical procedures. Indications for laparoscopy were duodenal atresias, volvulus with malrotation, pyloric stenosis, gastroesophageal reflux, cystic lymphangiomas, ovarian cysts, biliary atresia, and congenital diaphragmatic hernias; indications for thoracoscopy were esophageal atresias and tracheoesophageal fistula.

**Results.** Median operative time was 79 minutes. Mean insufflation pressure was 6.7 mm Hg (range: 3–13). Oxygen saturation decreased, especially with thoracic insufflation or high-pressure pneumoperitoneum. Systolic arterial pressure, which decreased in 20% of the patients, was controlled easily with vascular expansion. Thermic loss (mean postoperative temperature: 35.6°C) was proportional to the duration of insufflation. No surgical incident was noted. Ten anesthetic incidents occurred (20%), 3 of which required temporary or definitive interruption of insufflation (O₂ saturation <70%). Risk factors for an incident were low preoperative temperature, high variation of end-tidal pressure of CO₂, surgical time >100 minutes, thoracic insufflation, and a high oxygen or vascular expansion requirement at the beginning of insufflation.

**Conclusion.** The neonate’s high sensitivity to insufflation is an important limiting factor of video-surgery. The described profile of the neonate at risk may help to reduce the frequency of adverse effects of this technique and improve its tolerance. Pediatrics 2005;116:e785–e791. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2005-0650; laparoscopy, minimally invasive surgery, thoracoscopy, neonate.

**ABBREVIATIONS.** ETCO₂, end-tidal pressure of CO₂; O₂ sat, oxygen saturation; HR, heart rate; PIP, peak inflating pressure.

After the success of minimally invasive surgical techniques in adults, application in pediatric patients was a logical next step. The use of these techniques in young children spread slowly, however, because the surgical instruments had to be downsized, the learning curve was relatively long, and safe and reliable anesthetic procedures had to be developed to ensure good tolerance of pneumoperitoneum and pneumothorax. Recently, progress has accelerated and the number of procedures that are being performed in children is rising rapidly. More than 40 indications for video-surgery are currently listed, the most widely acknowledged of which are the cholecystectomy, fundoplication for gastroesophageal reflux, and splenectomy.

Increasingly younger patients now benefit from these techniques, with laparoscopy and thoracoscopy in neonates among the most recent applications. Nevertheless, the potential impact of carbon dioxide pneumoperitoneum and pneumothorax on an immature neonatal cardiopulmonary system is a matter of great concern. Relatively few studies reporting on the cardiorespiratory consequences have been published, and most of those that support the feasibility and the safety of these methods in the first month of life are case reports or short clinical series. The advent of this new surgical procedure in such young children, given their cardiovascular, pulmonary, and thermoregulatory specificities, nevertheless requires a thorough evaluation of its tolerance. The aims of this study were to evaluate the respiratory, hemodynamic, and thermic effects of video-surgery in the first month of life and to determine the risk factors associated with peri- and postoperative complications.

**METHODS**

**Patients**

From January 1994 to September 2004, 49 neonates who were undergoing 50 laparoscopic or thoracoscopic procedures in our Department of Pediatric Surgery were enrolled in this study. The indications were congenital or acquired gastrointestinal, thoracic, or genital pathologies and are summarized in Table 1. The mean age was 11 days (range: 0–28 days), and body weight ranged from 2130 to 4750 g (mean: 3285 g). The gender ratio was 2 girls to 1 boy. Eight percent of the infants were premature, but the causes (maternal–fetal infection, ruptured membranes, etc) were in all cases independent of the pathology requiring surgery. The preoperative hemodynamic status was stable in all patients. Those with mal-
formation underwent extensive preoperative examination, including cerebral ultrasonography, Doppler echocardiography, and cardiologic consultation if needed. In all cases, the parents were informed of the standard surgical procedure and the advantages and risks of video-surgery. We excluded all newborns who required emergency surgery and had unstable preoperative hemodynamic status. Exploratory laparoscopies for diagnostic or biopsy purposes (eg, exploration of the biliary tract, liver biopsy) were also excluded, and only cases of therapeutic video-surgery were retained.

**Surgical and Anesthetic Methods**

The standard procedure for trocar insertion was always performed with an open technique for laparoscopy and with a Veress needle for thoracoscopy. A 3.5- to 5-mm scope with 0-degree or 30-degree vision was used. Two to 4 operative trocars were necessary. Most of the ports were 3.5 mm for 2.7-mm instruments. Anastomoses were performed with intracorporeal-knotted stitches using 5/0 resorbable sutures. The procedures for each indication are summarized in Table 1.

**TABLE 1. Indications for Laparoscopy and Thoracoscopy in 39 Neonates**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Procedure</th>
<th>No. of Cases</th>
<th>Surgical Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laparoscopy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal ovarian cysts</td>
<td>Resection of cysts (14) or ovariectomy (6)</td>
<td>20</td>
<td>No relapse, no second procedure required. Immediate closure without prosthetic</td>
</tr>
<tr>
<td>Congenital diaphragmatic hernia*</td>
<td>Reduction of hernia, diaphragmatic closure</td>
<td>6</td>
<td>material. Conversion to laparotomy in 3 cases (difficult to expose as a result of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>diluted bowel loops or liver). Postoperative chylothorax in 1 case.</td>
</tr>
<tr>
<td>Duodenal atresia</td>
<td>Duodeno-duodenal anastomosis</td>
<td>6</td>
<td>Neither postoperative fistula nor stenosis.</td>
</tr>
<tr>
<td>Volvulus with malrotation</td>
<td>Reduction of volvulus and Ladd procedure</td>
<td>5</td>
<td>Early postoperative feeding. Residual Ladd bands in 1 case. Conversion to</td>
</tr>
<tr>
<td>Ileal atresia, duplication, or</td>
<td>Ileo-ileal anastomosis</td>
<td>3</td>
<td>laparotomy if &gt;3 turns of volvulus.</td>
</tr>
<tr>
<td>cystic lymphangioma</td>
<td></td>
<td></td>
<td>No postoperative complication. Feeding well tolerated.</td>
</tr>
<tr>
<td>Hypertrophic pyloric stenosis</td>
<td>Pyloromyotomy</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Gastroesophageal reflux†</td>
<td>Fundoplication (Nissen)</td>
<td>1</td>
<td>Resolution of reflux symptoms.</td>
</tr>
<tr>
<td>Extralobar biliary atresia</td>
<td>Hepato-enterotomy</td>
<td>1</td>
<td>Complete regression of clinical and biological signs of cholestasis. No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>complication of the hepatojugal anastomosis.</td>
</tr>
<tr>
<td>Thoracoscopy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esophageal atresia</td>
<td>Tracheoesophageal fistula closing and</td>
<td>5</td>
<td>Immediate esophageal anastomosis in 4 cases. No anastomotic leakage. Esophageal</td>
</tr>
<tr>
<td></td>
<td>esophageal anastomosis</td>
<td></td>
<td>stenosis in 1 case.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cul-de-sac was only approximated in 1 case with long gap atresia.</td>
</tr>
<tr>
<td>Tracheoesophageal fistula</td>
<td>Tracheoesophageal fistula closing</td>
<td>1</td>
<td>Definitive closure of fistula.</td>
</tr>
</tbody>
</table>

One patient had an esophageal atresia and a duodenal atresia.
* Operated on for respiratory compromise and after stabilization of pulmonary hypertension.
† The indication for surgical treatment of gastroesophageal reflux was severe and threatening complications with cardiorespiratory symptoms.

The standard procedure for trocar insertion was always performed with an open technique for laparoscopy and with a Veress needle for thoracoscopy. A 3.5- to 5-mm scope with 0-degree or 30-degree vision was used. Two to 4 operative trocars were necessary. Most of the ports were 3.5 mm for 2.7-mm instruments. Anastomoses were performed with intracorporeal-knotted stitches using 5/0 resorbable sutures. The procedures for each indication are summarized in Table 1.

Premedication consisted of rectal Atropine (Renaudin, Itxassou, France) 20 μg/kg. An inhaled induction was performed with 7% sevoflurane (Sevorane [Abbott, Rungis, France]) in air and oxygen. A catheter was placed preoperatively in a major vein in all cases of intestinal atresia or diaphragmatic hernia and in low-weight infants who were at risk for hemodynamic instability. Muscle relaxation was needed for 53% of the patients (atrocurium; Tracrium [Glaxo-Smith-Kline, Marly-Le-Roi, France]; 0.5 mg/kg). This was done either immediately (principally for abdominal surgery because of insufficient working space) or at the surgeon’s request (elevated insufflation pressure). Periural anesthesia with ropivacaine (Naropin [Astra-Zeneca, Rueil-Malmaison, France]; 1 mL/kg, dilution 2 mg/mL) completed the analgesia for surgery of the lower pelvis (ovarian cyst).

A controlled ventilation initially maintained the tidal volume at 10 mL/kg until hypercapnia developed. The respiratory and hemodynamic perturbations caused by insufflation were evaluated by monitoring end-tidal pressure of CO2 (ETCO2), oxygen saturation (O2 sat; pulse oximetry), heart rate (HR), and blood arterial pressure (measured noninvasively with an automatic electronic sphygmomanometer). The adjustments in ventilatory minute volume and peak insufflating pressure (PIP), to ensure an ETCO2 <40 mm Hg and O2 sat >90%, were recorded every 5 minutes. The volume of fluid that was administered to maintain arterial systolic blood pressure >50 mm Hg was also measured. In cases of persistent alterations in ventilatory or hemodynamic constants, we noted the time to return to baseline values after the end of the insufflation. Rectal temperature was monitored continuously.

Conversion to open surgery and any surgical or anesthetic incidents were recorded, including the precipitating factor and consequences. Finally, the short-term postoperative course was studied (wearing of mechanical ventilation, length of stay in intensive care).

**Statistical Methods**

χ² tests for qualitative data and Student’s t tests for quantitative data were used with SPSS 11.1 software (SPSS Inc, Chicago, IL). Tests for equal variances and 1-tailed tests were applied. Significance was accepted at the P < .05 level.

**RESULTS**

All procedures were performed with insufflation, with the duration and pressure of CO2 pneumoperitoneum and pneumothorax varying according to the surgical indication. The mean time was 79 minutes (range: 10–190 minutes), and the mean pressure was 6.7 mm Hg (range: 3–13 mm Hg), with a maximum output of 6 L/min. For pneumothorax, the insufflation pressure ranged from 5 to 8 mm Hg (mean: 7 mm Hg, 125 minutes).

**Respiratory Consequences of Insufflation (Table 2)**

O2 sat decreased in 29 (58%) patients, from 99.1% ± 0.8 to 94.2% ± 4.8 (P < .01). In most of these infants, the decrease was moderate and O2 sat remained >90%. It returned to its preoperative value.
during surgery in 12 cases, but a moderate hypoxia, between 90% and 95%, persisted in 8 children despite high fraction of inspired \( O_2 \) (\( \geq 75\% \)) with a spontaneous correction within 15 minutes of the end of insufflation. However, the \( O_2 \) sat decreased markedly under correction within 15 minutes of the end of insufflation. In 56% of the cases, hyperventilation did not completely correct the ETCO\(_2\), and \( O_2 \) sat decreased markedly under 80% in 4 cases. The insufflation was temporarily interrupted in 2 cases (\( O_2 \) sat \(< 70\% \)) to restore an acceptable saturation level and definitively stopped in 1 case. The greatest alteration in \( O_2 \) sat was observed during thoracic insufflation for thoracoscopic procedures (eg, esophageal atresia), with a mean decrease of 12.4% (maximum: 21%). These perturbations were significantly greater than during abdominal insufflation (\( P < .01 \)). Per-operative correction nevertheless was reached in all cases once the tracheoesophageal fistula was closed.

ETCO\(_2\) increased in 88% of the cases by an average of 9.1 \( \pm \) 5.3 mm Hg. The increase was considered to be high in 8 cases (>15 mm Hg) and very high in 3 cases (>20 mm Hg). In 56% of the cases, hyperventilation did not completely correct the ETCO\(_2\), and the return to the baseline value was reached only at the end of the insufflation; this occurred within 15 minutes in all cases. Both the pressure and the duration of CO\(_2\) insufflation influenced the variations in ETCO\(_2\). The smallest variations were observed with insufflation <6 mm Hg, and the ETCO\(_2\) was significantly correlated to insufflation pressure (\( P < .05 \); Fig 1). These variations tended to be greater in cases of long procedures (\( P > .05 \); Fig 2). In 84% of the cases, an increase in ventilatory minute volume was needed to limit the perturbations once insufflation began (mean: 22.6%). The tidal volume increased from 33.4 \( \pm \) 12.1 mL to 38.5 \( \pm \) 12.5 mL (\( P < .05 \)), and the PIP increased from 17.3 \( \pm \) 4.0 cm H\(_2\)O to 22.2 \( \pm \) 5.4 cm H\(_2\)O (\( P < .05 \)).

Despite these ventilatory alterations, extubation on the operating table was possible in 60% of the patients. Nineteen infants required postoperative ventilatory assistance, however (mean: 3 days; range: 1–6 days). These were neonates with severe malformative disease (esophageal atresia) or pulmonary consequences of their pathology (diaphragmatic hernia), or they presented respiratory distress at extubation (Table 3).

### Cardiovascular Consequences of Insufflation

In 80% of the children, the systolic blood pressure was stable during insufflation (with no variation or <5 mm Hg). In these patients, an increase in HR nevertheless was observed (from 128 \( \pm \) 15.9 to 140 \( \pm \) 16.3 beats per minute; \( P < .05 \)). This phenomenon was either transitory or resolved quickly when pneumoperitoneum was stopped. In 20% of the patients, blood pressure decreased by 10 mm Hg or more. Nine infants required per-operative vascular expansion with 4% albumin because of systolic blood pressure <45 mm Hg. In all cases, this single expansion was sufficient. The variation in arterial blood pressure tended to be greater in cases of esophageal...
atresia and congenital diaphragmatic hernia than in other indications (−4.4 vs −1.6 mm Hg; not significant).

Thermic Consequences of Insufflation

The postoperative core body temperature was <36°C in 50% of the patients and <34.5°C in 12%. For 1 infant, the hypothermia (33.6°C) was complicated by an episode of bradycardia. Linear regression analysis according to the Pearson test showed a low but significant correlation (r = .4, P < .05) between the length of surgery and decreased temperature. The per-operative temperature loss in degrees Celsius was 0.01 of the surgical time in minutes (Fig 3). This loss was not influenced by the patient's age at the time of surgery or by weight.

Per-Operative Incidents and Risk Factors

We report no surgical incidents in our series, such as vascular lesion or intestinal perforation. No emergency conversion to laparotomy was needed. However, 10 insufflation-related incidents occurred: 5 minor incidents that did not require interruption of insufflation and 5 more threatening incidents. The incidents, causes, and outcomes are summarized in Table 3. The risk factors or events that were significantly linked to the occurrence of an incident were low preoperative body temperature, high variation of ETCO2, high PIP after insufflation, an inspiratory oxygen fraction = 100% necessary from the start of surgery, and more frequent need of vascular expansion to maintain correct hemodynamic status (Table 4). Prematurity was not a risk factor for an incident. The premature infants (8% of the cases) nevertheless were extubated later than the others (3 ± 3 vs 0.9 ± 2.9 days; P < .05), whatever the surgical indication (ovarian cyst, diaphragmatic hernia).

Fourteen (32%) of the surgical procedures lasted >100 minutes. The ratio of laparoscopies (n = 10) to thoracoscopies (n = 4) did not differ significantly from that of the shorter surgeries (<100 minutes). Long operative time was associated with lower postoperative core body temperature; higher PIP increase; more frequent incidents, both minor and major; and more frequent stays in intensive care (Table 5).

The effects of pneumothorax were assessed in 6 patients. When compared with pneumoperitoneum, the initial required inspiratory fraction of oxygen was higher (100% fraction of inspired O2 for the thoracoscopies vs 58% for the laparoscopies; P < .01), and vascular expansion was more often required (75% of the patients for the thoracoscopies vs 25% for the laparoscopies; P < .01). The frequency of incidents was also higher for thoracoscopy than for laparoscopy (60% vs 13%). The incidents occurred notably in cases of large permeable tracheoesophageal fistulas.

**DISCUSSION**

The use of minimally invasive surgery has been expanding steadily in pediatric surgical practice. Although it has been difficult to prove that infants who undergo this technique have a shorter and simpler postoperative course, some indications such as the fundoplication5 have clearly shown better cosmetic results and more rapid recovery. Neonates, however, have distinct physiologic and anatomic characteristics that increase the rate of surgical complica-

### Table 3. Cause, Treatment, and Outcome of Incidents Encountered in 8 Neonates During Video-Surgery

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Frequency</th>
<th>Cause</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotensive episode</td>
<td>3</td>
<td>Initial insufflation</td>
<td>Temporary reduction of insufflation pressure</td>
<td>Spontaneous correction, no relapse</td>
</tr>
<tr>
<td>Moderate desaturation (O2 sat &gt;80%)</td>
<td>1</td>
<td>Initial insufflation</td>
<td>FiO2 at 100%</td>
<td>Complete and quick recovery (&lt;10 min)</td>
</tr>
<tr>
<td>Severe desaturation (O2 sat &lt;70%)</td>
<td>3</td>
<td>Initial insufflation</td>
<td>Insufflation stopped, ventilation with 100% O2</td>
<td>Video-surgery continued in 2 cases, stopped in 1 case</td>
</tr>
<tr>
<td>Bradycardia with hypothermia</td>
<td>1</td>
<td>Length of surgery</td>
<td>Per-operative warming</td>
<td>Per-operative correction of bradycardia</td>
</tr>
<tr>
<td>Respiratory distress at extubation</td>
<td>2</td>
<td>Bilateral superior atelectasis</td>
<td>Re-intubation, kinesiotherapy</td>
<td>Extubation at day 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardiac malformation*</td>
<td>Re-intubation</td>
<td>Extubation at day 2</td>
</tr>
</tbody>
</table>

FiO2 indicates fraction of inspired oxygen.
* Not noted during the preoperative work-up; surgical correction of the malformation required.

![Fig 3. The decrease in body temperature during surgery is proportional to the length of insufflation (linear regression analysis, P < .05).](image-url)
lated with high CO2 arterial pressure and low 

ation of the cerebral circulation because it is corre-

infant to the risk of per-operative acidosis and alter-

factor for preoperative incident. It may expose the 

populations by Fujimoto et al.10 This study was de-

reduced per-operative stress demonstrated in older 

not been used widely in these patients, despite the 

insufflation in small infants is overall acceptable.13–15 The peritoneal and pleural absorption 

adjustment, was higher than that observed in 

above 13 mm Hg, and the stability of the arterial 

Nevertheless is advocated because tolerance is unknown 

all stable. The variation was null or <5 mm Hg in 

80% of the cases. The use of minimal pressure nev-

arrested at the end of anesthesia. Nevertheless, 

the length of insufflation clearly influences the depth 

hypothermia. Postoperative hypothermia was frequent and the 

final temperature was <35°C in 25% of the infants. The heightened sensitivity to hypothermia in the 

newborns, caused by an increased caloric loss and a 

per-operative drop in thermogenesis, was aggra-

vated by the frequently prolonged surgical times and the use of cold and dry gas.26–29 This hypothermia 

was well tolerated (only 1 case of bradycardia) and 

limited by the use of external heat sources (radiant 

lamps, pulsed air blankets). In all cases, it was rap-

ily corrected at the end of anesthesia. Nevertheless, 

the length of insufflation clearly influences the depth 

hypothermia. Technical innovations, advances in miniaturiza-

tion, and experience have made laparoscopy and 

thoracoscopy safer and easier.30,31 Numerous publi-

ations have demonstrated the feasibility of these 

techniques in newborns. The major problem today is 

the need to establish criteria that distinguish neo-

nates who will benefit from the techniques from 

those with a low tolerance for insufflation. A profile 

of the neonatal patient who is at risk for an insuffla-

tion-related incident emerged from our series: ini-

tially low body temperature, high variations of 

ETCO2, a need for vascular expansion, and major 

alterations have demonstrated the feasibility of these 

techniques. Bozkurt et al23 confirmed the stability 

of arterial systolic pressure after 30 minutes of insuf-

lation at <10 mm Hg in 27 infants of 1 month to 1 

year. No hemodynamic instability in newborns was 

reported with an insufflation pressure of 8 mm Hg.10 

In our series, the systemic arterial pressure was over-

all stable. The variation was null or <5 mm Hg in 

80% of the cases. The use of minimal pressure nev-

theless is advocated because tolerance is unknown 

above 13 mm Hg, and the stability of the arterial 

pressure does not exclude alterations of the cardiac 

output.24,25 

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of hypothermia. Technical innovations, advances in miniaturiza-

10) 

11,12 Laparoscopy and thoracoscopy thus have 

not been used widely in these patients, despite the 

reduced per-operative stress demonstrated in older 

populations by Fujimoto et al.10 This study was de-

signed to evaluate the repercussions of CO2 insuffla-

tion in infants who are younger than 1 month and to 

determine the characteristics of patients who are at 

risk for complication.

Neonatal ventilatory limitations, particularly the 

small airway caliber and the important instrumental 

deadspace, could explain the markedly perturbed 

gas exchanges noted in our series. The 33% increase 

in ETCO2 over its initial value, despite ventilatory 

adjustment, was higher than that observed in 

adults.13–15 The peritoneal and pleural absorption 

surface per unit of weight is high in newborns.16 The 

low quantity of peritoneal fat and the slight distance 

between vessels and the serous surface increase the 

permeability of the peritoneum to CO2. We found 

that the ETCO2 was all the more heightened with 

high-pressure, thoracic, and long-duration insuffla-

tion and that a major increase in ETCO2 was a risk 

factor for preoperative incident. It may expose the 

infant to the risk of per-operative acidosis and alter-

ation of the cerebral circulation because it is corre-

related with high CO2 arterial pressure and low 

pH.17,18 

For controlling ETCO2 and counterbalancing a 

reduced respiratory compliance induced by insuffla-

tion,19 a great increase in ventilatory minute volume 

(22.6% in our series, 40% for Fujimoto10) and PIP was 

essential. However, it was applied to neonatal lungs 

that are highly sensitive to both volume and pres-

sure. Although it is likely that the long-term con-

sequences are minimal, given the short duration of the 

mechanical ventilation, this remains to be demon-

strated.

Despite a low compliance in the neonatal myocar-

dia,20 a low functional reserve, and heightened sen-

sitivity to changes in systolic pressure and teledias-

tolic volume,21 the hemodynamic tolerance of insufflation in small infants is overall acceptable. 

Gueugniaud et al22 evaluated the cardiac perform-

ance in infants of 6 to 30 months by per-operative 

cardiac echography and showed that the variations 

of cardiac output were without threatening clinical 

consequences. Bozkurt et al23 confirmed the stability 

of cardiac output were without threatening clinical 

cardiac echography and showed that the variations 

of arterial systolic pressure after 30 minutes of insuf-

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tion-related incident emerged from our series: ini-

tially low body temperature, high variations of 

ETCO2, a need for vascular expansion, and major 

modification in the oxygen inspiratory fraction or 

TABLE 5. Effects of Video-Surgical Procedures Longer Than 100 Minutes in Neonates

<table>
<thead>
<tr>
<th></th>
<th>Surgery &lt;100 Min</th>
<th>Surgery &gt;100 Min</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative body temperature, °C</td>
<td>35.8 ± 0.5</td>
<td>34.1 ± 1.1</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>PIP increase, cm H2O</td>
<td>2.7 ± 3.4</td>
<td>9 ± 4.1</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Frequency of incidents, %</td>
<td>11.4 (n = 4)</td>
<td>42.8 (n = 6)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Frequency of postoperative intensive care, %</td>
<td>25.7 (n = 9)</td>
<td>71.4 (n = 10)</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

Data are mean ± SD.
PIP at the start of insufflation. When surgery unfolds in a neonate who presents these risk factors, the surgeon and the anesthesiologist should be aware that this patient is at a heightened risk for poor tolerance of the procedure. The correction of hypothermia by external warming, a reduction in the length of surgery if at all possible, and close surveillance of the hemodynamic and ventilatory status are strongly advised.

Other circumstances appeared as aggravating factors in our series. The neonates were more sensitive to thoracoscopy than laparoscopy. Pneumothorax required ventilation with a higher oxygen fraction and more frequent vascular expansion. The direct pressures on the lung and heart may impair more extensively the gas exchanges and the cardiac output. Incidents thus were more frequent with thoracoscopy. The surgical indications for thoracoscopy (esophageal atresia, tracheoesophageal fistula) may also be aggravating factors because a part of the ventilation is lost through the fistula until it is closed. Some authors thus have proposed 1-lung ventilation for thoracoscopy in small infants to avoid pressure in the chest from insufflation. This pressure can affect cardiac performance and may even impair contralateral lung function. One-lung ventilation has the advantage of providing good surgical exposure without the need to mechanically push back the contralateral lung and/or use insufflation to retract it into the pleural cavity. However, 1-lung ventilation has never been described in neonates and would seem to pose some technical difficulties. Double-lumen endotracheal tubes of an adapted size are lacking. Bronchial blocking carries the risk for displacement of the blocker, causing tracheal obstruction because of the small size of the airways. Injury during bronchial blocking by nonspecific material such as the Fogarty balloon catheter is another risk, notably because of the high pressure generated by the balloon. We observed a bronchial perforation caused by a Fogarty catheter in a young infant in our department (unpublished observation). Moreover, tolerance of thoracic video-surgery in very small children is worse under 1-lung ventilation than 2-lung ventilation. It should also be noted that tracheal ventilation facilitates the detection of a tracheoesophageal fistula during the surgical repair of esophageal atresias, in which case, selective intubation would be inappropriate. Last, insufflation of the pleural cavity, which is required to obtain a partial retraction of the lung, is accomplished with the same order of pressure as the intermittent positive intrathoracic pressure generated by mechanical ventilation.

Another risk factor of poor tolerance was the length of surgery. More than 100 minutes of insufflation required very close follow-up because of the heightened risks for hypothermia, anesthetic incidents, temporary interruption of insufflation, and delayed extubation. In contrast, patients’ age and weight were not determining factors for insufflation tolerance.

Despite the diversity of surgical procedures seen in our series, this study points out the neonate’s high sensitivity to insufflation as the main limitation to video-surgery. The pattern of the at-risk patient that emerged is as follows: a neonate undergoing thoracoscopy for >100 minutes, with high insufflation pressures and ETCO₂ variations, low body temperature, a need for vascular expansion, and major modification in ventilatory parameters at the start of insufflation. In addition to the widely reported feasibility of neonatal video-surgery, knowledge of these risk factors and precursor signs of incidents may help to improve the tolerance of this technique during the first month of life.

REFERENCES


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