The assessment of intra-abdominal pressure with the Polish prototype of intra-bladder pressure gauge – the own experience

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Abstract
The abdominal compartment syndrome (ACS) results from an acute increase of intra-abdominal pressure and may lead to severe organ dysfunction. The authors described their own experience of measurement of intra-abdominal pressure as a prevention of ACS with use of intra-bladder pressure (IBP) gauge of own conception and construction. The IBP was measured during operations and postoperative period of 100 patients by a Polish gauge constructed in Technical University of Łódź. Since December 2000 through November 2007 we measured IBP in 100 patients (85 newborns, 15 children from 1 to 3 years old) operated on because of: gastroschisis – 52, omphalocele – 24, congenital diaphragmatic hernia – 9, abdominal wall hernia after primarily non-surgical treatment of giant omphalocele – 15. In 13 patients who underwent staged repair postoperative IBP measurement decided of timing, frequency and extent of silo reductions and timing of final abdominal closure. We did not observe symptoms of abdominal compartment syndrome in our patients, there were no deaths as a result of complications due to high intra-abdominal pressure since the introduction of IBP measurement. Conclusions: 1) We recommend measurement of IBP as an objective, non-invasive and simple method to evaluate the intra-abdominal pressure and prevention of abdominal compartment syndrome. 2) Intra and postoperative measurement of IBP helps to avoid the compartment syndrome and its dire consequences.

Key words: abdominal compartment syndrome, intra-abdominal pressure, intra-bladder pressure, abdominal wall defects, diaphragmatic hernia

Background
Newborns treated because of abdominal wall defects: gastroschisis (G), omphalocele (O) and congenital diaphragmatic hernia (CDH) are at risk of severe complications from markedly increased intra-abdominal pressure (IAP) occurring in these diseases after operation [1-14]. The elevation of IAP causes a significant decrease in blood pressure and cardiac output resulted in renal failure, intestinal necrosis, respiratory distress and may lead to development of abdominal compartment syndrome (ACS) [15]. The measurement of intra-bladder pressure is one of several methods of indirect assessment of the IAP [3, 6, 16-19].

We described our experience of measurement of IAP as prevention of ACS during operation and postoperative period with the use of our own intra-bladder pressure gauge.

Materials and methods
Since December 2000 through November 2007 we assessed IAP during operations of newborns with congenital abdominal wall defects (gastroschisis, omphalocele), diaphragmatic hernia and children with abdominal wall hernia after primarily conservative treatment of giant omphalocele in order to prevent ACS. We assessed intrabladder pressure (IBP) using a gauge constructed in cooperation with engineers from Technical University of Łódź.

Thanks to the small size and its own source of energy (from battery) the IBP gauge can be used in the operation room as well as at the bed side or inside incubator during postoperative period. A Foley catheter inserted in the bladder is connected through standard catheters with electronic pressure measuring cup which transforms IBP into the electronic impulse showed on the screen of the device. Just before measurement, all the system is filled with 0,9 % NaCl (Fig. 1).

Fig. 1. The Polish gauge for measurement of intra-bladder pressure

The rate of IBP determined the methods of surgical treatment (one or multistage procedure) and using prosthetic materials. The postoperative IBP monitoring helped to decide on the type of medical treatment (sedation and paralysis).
Results

Since December 2000 through November 2007 we measured IBP in 100 patients: 52 with gastroschisis (G), 24 with omphalocele (O), 9 with diaphragmatic hernia (CDH) and 15 with abdominal wall hernia after non-surgical treatment of large omphalocele (AH). Children from first three group were newborns – 85 patients, from the last one children 1 to 3 years old – 15 patients (Table 1).

Table 1. Number of patients and type of anomaly

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>CDH</th>
<th>G</th>
<th>O</th>
<th>AH</th>
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<td>6</td>
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<td>2006</td>
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<td>7</td>
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<td>4</td>
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<tr>
<td>2007</td>
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<td>8</td>
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</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>52</td>
<td>24</td>
<td>15</td>
</tr>
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</table>

CDH – congenital diaphragmatic hernia, G – gastroschisis, O – omphalocele, AH – abdominal hernia after non-surgical treatment of giant omphalocele

In spite of generally accepted methods of assessment of IAP still the choice of operative and postoperative treatment is determined by clinical impressions rather than objective measurements.

There are several methods of indirect assessment of the IAP: 1) intra-gastric pressure (IGP), 2) intra-bladder pressure (IBP), 3) central venous pressure (CVP), 4) peak inspiratory pressure (PIP). None of them is excellent. The CVP measurement brings the potential risk of infection and thrombosis from intravenous catheters [3, 17, 19-21]. The IGP monitoring relies on a system that is open at both ends (the esophageal and duodenal outlets of the stomach) and is less accurate than in a closed circuit. Moreover, there is a risk of gastrointestinal reflux and aspiration of gastric contents [3, 5, 16, 17, 19, 21-23].

The IBP monitoring has some disadvantages, too. This method may lead to the urinary infections and stricture of urethra from urethral catheters. On the other hand, a Foley catheter is routinely inserted in the most newborns to monitor urine output and when it is done with the strict aseptic regime it should not cause any risk of urinary infection. We did not observe any above mentioned complications in our patient [3, 6, 16, 17, 19, 20, 22, 24-29].

Based on previous animal and clinical studies which showed significantly decreased organ perfusion when IAP reached 20 mm Hg (27 cm H$_2$O) we assumed this level IAP as critical one and in order to prevent ACS we did not close primarily abdominal wall if IAP was higher than 20 mm Hg (27 cm H$_2$O).

It is suggested that patients with IBP between 10 and 15 mm Hg (13.5-20.3 cm H$_2$O) should received heavy sedation, while paralytic agents should be administered only to those patients in which IBP rose above 15 mm Hg (20.3 cm H$_2$O). The IBP monitoring should be discontinued when the IBP remain less than 10 mm Hg (13.5 cm H$_2$O) for 24-hour period without sedatives.

According to these principles we used to choose a method of closure of abdominal wall defects or timing and kind of conservative treatment during postoperative period [20, 29].
Thanks to the measurement of intra-bladder pressure we prevented a development of abdominal compartment syndrome in our patients.

**Conclusion**

1) We recommend measurement of intra-bladder pressure as an objective, non-invasive and simple method to evaluate the intra-abdominal pressure and prevention of abdominal compartment syndrome.

2) Intra and postoperative measurement of intra-bladder pressure helps to avoid the compartment syndrome and its dire consequences.

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