Intra-Abdominal Hypertension and Abdominal Compartment Syndrome Following Surgery for Ruptured Abdominal Aortic Aneurysm

K. Djavani,1-2* A. Wanhainen1 and M. Björck1

Departments of Surgery, 1Uppsala University Hospital, Uppsala, and 2Gävle County Hospital, Gävle, Sweden

Objectives. To investigate the importance of intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS), based on the December 2004 consensus definition, on outcome after surgery for ruptured abdominal aortic aneurysm (rAAA).

Methods. Twenty-seven patients underwent open surgery for rAAA after the introduction of intra-abdominal pressure (IAP) measurements among patients at risk of IAH. Case-records were reviewed retrospectively. Seventeen patients underwent IAP-monitoring.

Results. Of eight patients with IAP <21 mmHg none developed colonic ischaemia or ACS. Of four patients with IAP 21–25 mmHg (IAH grade III), two underwent colonic resection. One patient treated with open abdomen died from cardiac arrhythmia. Five patients had IAP >25 mmHg (IAH grade IV). All developed ACS. Two were not decompressed and both developed pulmonary complications, one died. Two underwent colonic resection and one was treated with open abdomen, all three survived. Of 10 patients not monitored for IAP, one died of cardiac complications, but no patient developed signs of colonic ischaemia or ACS. Mortality at 30 days and 1 year was 3/27 (11%).

Conclusion. IAH and ACS were common among patients undergoing surgery for rAAA. The ACS consensus definition seems appropriate in this clinical context. Monitoring IAP, and timely decompression of patients with IAH might improve outcome after surgery for rAAA.

Keywords: Intra-abdominal pressure; Intra-abdominal hypertension; Abdominal compartment syndrome; Aortic aneurysm-abdominal; Intestinal ischaemia-colonic.

Introduction

Elevated intra-abdominal pressure (IAP) has been recognized increasingly as a cause of significant morbidity and mortality in critically ill patients.1-3 Raised intra-abdominal pressure previously has been poorly defined, but as the pressure increases, a spectrum of physiological effects are observed. Intra-abdominal hypertension (IAH) may develop into abdominal compartment syndrome (ACS).4 ACS has been identified an independent predictor for multiple organ failure (MOF) and prevention of ACS decreases the incidence of MOF after trauma.5,6

The mortality rate after ruptured abdominal aneurysm (rAAA) remains high, with MOF representing a leading cause of death in patients who survive operative repair.7-8 Therapeutic interventions based on IAP measurements, such as restoration of volume status and abdominal decompression, may be important in reversing ongoing organ failure and preventing further harm.9

Historically, there has been some confusion regarding how to measure IAP, the definition of intraabdominal hypertension (IAP) and of ACS. After the Consensus Definition was established by the World Society on the ACS in December 2004, this is no longer a problem.10

The aim of this pilot study was to investigate retrospectively the incidence and clinical consequences of IAH and of ACS, according to the Consensus Definition,10 after surgery for r-AAA.

Patients and Methods

Between January 2002 and March 2003, 75 patients underwent surgery for AAA at the University Hospital of Uppsala, Sweden. Three patients had
AAA of the suprarenal aorta, 17 had elective EVAR, 20 elective open repair and eight underwent urgent repair without rupture. All these were excluded from analysis. The remaining 27 patients who underwent open repair for an infrarenal rAAA are the basis of this report. The rationale to study this time-period was that a prospective study on IAH and ACS after rAAA-surgery was initiated in April 2003. The patients had a mean age of 72 years, 22 were men and five women. Among preoperative risk-factors 22 (81%) had hypertension, 17 (63%) cardiac disease, 12 (44%) pulmonary disease, five (18%) cerebrovascular disease, two (7%) diabetes mellitus and two had renal insufficiency, defined as having a preoperative serum creatinine above 150 μmol/l.

Seventeen patients had IAP monitored in the bladder every 4 h postoperatively, during 6 days (mean) on the intensive care unit. The selection for IAP measurement was based on perioperative factors. Patients with uncomplicated events, such as contained rupture without shock, who were extubated immediately postoperatively, were not considered for IAP measurement. Measurement of IAP was performed indirectly intra-vesically by connecting the aspiration port of the urinary catheter to a pressure transducer after having installed 50 ml of saline into the bladder, and results are reported in mmHg (1 mmHg = 1.36 cmH2O), as recommended by the consensus definition.

Patients who needed inotropic intravenous support for more than 48 h were defined as having cardiac failure, those in need of mechanical ventilation for more than 48 h as having respiratory failure and those requiring dialysis were defined as having renal failure. Colonoscopy was performed as necessary. Case-records were reviewed retrospectively.

Mortality after surgery for rAAA in Uppsala was compared between to that in the official yearly report from the Swedish National Registry for Vascular Surgery, Swedvasc, for 2003, published in 2004.

### Results

Perioperative data, clinical events and outcome for the 27 patients operated on for rAAA, according to IAP, are shown in Table 1.

<table>
<thead>
<tr>
<th>IAP (mmHg)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAP</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Perioperative bleeding (mean litres)</td>
</tr>
<tr>
<td></td>
<td>Cross clamp time (mean minutes)</td>
</tr>
<tr>
<td></td>
<td>Op time (mean minutes)</td>
</tr>
<tr>
<td></td>
<td>IAP monitoring (mean days)</td>
</tr>
<tr>
<td></td>
<td>ICU stay (mean days)</td>
</tr>
<tr>
<td></td>
<td>Antibiotic treatment (mean days)</td>
</tr>
<tr>
<td></td>
<td>Reoperation for bleeding</td>
</tr>
<tr>
<td></td>
<td>Colonic gangrene, reoperation with resection</td>
</tr>
<tr>
<td></td>
<td>Colonic mucosal gangrene</td>
</tr>
<tr>
<td></td>
<td>Treatment with open abdomen</td>
</tr>
<tr>
<td></td>
<td>Cardiac failure</td>
</tr>
<tr>
<td></td>
<td>Pulmonary failure</td>
</tr>
<tr>
<td></td>
<td>Renal failure</td>
</tr>
<tr>
<td></td>
<td>ACS</td>
</tr>
<tr>
<td></td>
<td>Discharged to home within 30 days</td>
</tr>
<tr>
<td></td>
<td>Mortality 30 days and 1 year</td>
</tr>
</tbody>
</table>

No IAP, IAP was not monitored; ACS, abdominal compartment syndrome is defined as IAP > 20 mmHg and any organ failure, according to the consensus definition.

In Swedvasc report for the year 2003, 263 patients underwent surgery for rAAA with a mortality of 27%, compared to 11% in Uppsala, mortality difference 15.9% (95% CI: 2.9–28.9%).

### Discussion

Although the importance of IAP is becoming increasingly recognized among vascular surgeons, few investigators have reported IAP measurements after AAA surgery. This study showed that IAH and ACS...
are common after surgery for rAAA. One limitation of our study is the fact that not all patients had IAP monitoring, only a subset of complicated cases. More than one third of the patients were not monitored for IAP. Since those with IAP monitoring were more seriously ill than those not monitored, it is impossible to discern whether IAP-monitoring improves outcome after rAAA surgery. Although the study was retrospective, a protocol for IAP-measurements was followed among those selected for IAP-monitoring, resulting in frequent and uniform measurements during the stay in intensive care.

Papavasiliou et al. studied 75 patients operated on for AAA. IAP was measured every 24 h when the patient was still on the ventilator. Among those operated for rAAA 12/22 (55%) had an IAP-value > 15 mmHg. Platell et al. measured IAP in 42 patients operated on for AAA. IAP was measured at 2, 4, 8, 14, 20 and 26 h after operation. Patients with renal impairment had significantly higher IAP measurement, and patients requiring re-exploration had a rising IAP and decreasing urinary output. They were able to show that an IAP of 18 mmHg predicted renal impairment with a predictive value of 85%, and a negative predictive value of 62%. Björk et al. reported 25 patients operated on for AAA, with IAP measured in bladder consistently every 6 h during the post-operative stay in intensive care. Four patients had isolated values above 18 mmHg without any clinical consequences and three had consistent prolonged IAH and were decompressed: two had colonic gangrene. Those patients who had prolonged IAH were all operated on for ruptured AAA. No patient died within 30d of surgery.

The association between colonic ischaemia and IAH was verified in this present study: all patients who developed colonic ischaemia also had raised IAP Decompression laparotomies were often life-saving, 5/6 survived (Table 1). The patient who died was lost due to an arrhythmia secondary to a perioperative myocardial infarction. One further patient with IAH in the range 25–29 mmHg and a fatal pulmonary complication might have benefited from a timely decompression.

Patients with IAH grade III or IV had more bleeding, longer cross clamping times and operative time compared to those with an IAP <21 mmHg and those not selected for IAP-monitoring, suggesting these factors as possible risk factors for IAH. Balogh et al. has previously shown that the administration of crystalloids is an independent predictor of ACS in trauma patients. We previously have shown that preoperative shock and massive blood-loss (> 10 l) are the most powerful risk-factors for postoperative colonic ischaemia after AAA surgery. Although it is difficult to draw firm conclusions from this pilot study, our results suggest that the selection criteria for IAP monitoring were appropriate.

There are many reasons why survival after surgery for rAAA in Uppsala appeared superior to that in the rest of Sweden and multiple confounding factors. Treatment of several patients with life-threatening colonic ischaemia and ACS might have contributed to this difference.

Since 7/9 patients (78%) with IAH grade III or IV, developed organ failure, and that all six patients who developed mucosal or transmural colonic gangrene had IAH, the consensus definition on ACS seems appropriate for patients after AAA surgery.

Prospective studies are required to study the association of IAH and colonic ischaemia and outcome, as well as the optimal timing of decompression. Results from a prospective study, started in April 2003, are awaited.

References

10. Intraabdominal hypertension (IAH) and the abdominal compartment syndrome (ACS). Results from the international ACS consensus definitions conference. Available at: http://www.wvasc.org.

Eur J Vasc Endovasc Surg Vol 31, June 2006


Accepted 10 December 2005
Available online 3 February 2006