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Original Research

Comparison of intra-abdominal pressure in open surgery and endovascular aortic repair procedures

Intra-abdominal pressure in aortic repair procedures

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Abstract

Aim: Surgery and endovascular aortic repair (EVAR) procedures performed in abdominal aortic aneurysm (AAA) disease can lead to increased intra-abdominal pressure (IAP). In this study, we aimed to determine IAP values in intact infrarenal AAA patients who underwent surgery and the EVAR procedure, and to contribute to the literature with our results.

Material and Methods: Thirty-six patients who underwent open surgery and EVAR treatment for infrarenal AAA between June 2018 and September 2021 were retrospectively analyzed.

The patients were divided into three groups. Group 1: Patients treated with open surgery and no drains; Group 2: Patients treated with open surgery in whom a drain was placed; Group 3: Patients treated with EVAR.

Results: Demographic data and comorbidities of the groups were similar. IAP values were lower in the EVAR procedure group (Group 3) compared to the other groups at each measurement period. This difference was statistically significant, especially at the postoperative 12th, 18th, and 24th hours (p<0.05). Among the groups that underwent open surgery, the postoperative IAP values in Group 2 were lower compared to Group 1.

Discussion: We found that placing a drain in patients undergoing open surgery is more beneficial to prevent IAP increase. However, endovascular surgery was much more effective than open surgical repair in preventing IAP increase.

Keywords

Abdominal Aortic Aneurysm, Intraabdominal Pressure, Endovascular Aortic Repair, Surgery

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Introduction

Intraabdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are pathological conditions that occur because of increased intra-abdominal pressure (IAP) and can result in mortality and morbidity. Kron et al. defined ACS as a term in four patients who underwent ruptured abdominal aortic aneurysm repair [1]. In 2004, the World Society of the Abdominal Compartment Syndrome put forward consensus definitions of ACS and IAP. The normal value of IAP was specified as 5-7 mmHg in critical adult patients. Intra-abdominal hypertension (IAH) was defined as IAP≥12 mmHg twice in consecutive measurements. ACS was defined as an acute increase in IAP above 20 mm, end-organ damage, abdominal pain, and improvement in the patient's condition after decompression [2,3] .

Risk factors for IAH and ACS were categorized into four categories, including decreased compliance of the abdominal wall, increased intraluminal content, increased intraabdominal content, capillary leak, and fluid resuscitation. It is important to know the risk factors that cause IAH and ACS to prevent end-organ damage [4]. One of these causes may be an abdominal aortic aneurysm or rupture. In the literature, there are studies on IAP increase in patients with abdominal aortic pathologies who underwent open surgical repair and endovascular treatment procedure [5-7].

Our study aimed to determine and compare the IAP values of patients who did and did not have drains placed in the open surgical approach and those who underwent EVAR procedure for the treatment of infrarenal AAA, and to contribute to the literature with our results.

Material and Methods

This study was conducted retrospectively in patients who underwent open surgery and EVAR treatment for abdominal aortic aneurysm. Patient data were obtained from the hospital data processing system and patient files. The patients were divided into three groups as follows:

Group 1: Patients treated with open surgery for intact infrarenal AAA in whom no intraabdominal drains were placed during the closure.

Group 2: Patients treated with open surgery for intact infrarenal AAA in whom an intraabdominal drain was placed during the closure.

Group 3: Patients treated with EVAR for intact infrarenal AAA

The groups were compared in terms of demographic data, comorbidities, radiological examination results, and intraabdominal pressure values. Intact infrarenal AAA patients over 18 years of age who underwent open surgery or EVAR were included in the study. Those younger than 18 years of age, patients who had infrarenal AAA rupture and dissection, and those whose data could not be reached were excluded.

Routine Monitoring and Related Parameters

Before starting open surgery or EVAR, the patients were monitored with electrocardiography, and pulse oximetry. The radial artery was catheterized from the nondominant arm for systemic arterial pressure measurement. Central venous pressure values were monitored in patients who had a central catheter inserted into the internal jugular vein using the Seldinger technique. After systemic heparinization, activated coagulation time was measured for anticoagulation follow-up. A Foley urinary catheter was placed in the bladder and urinary output was monitored in all patients. IAP values were measured using an unometer abdo-pressure sterile and noninvasive pressure monitoring system attached behind the bladder catheter (Figure 1). The first IAP was measured before the operation started. Postoperatively, it was performed and recorded sequentially as recommended by the World Society of the Abdominal Compartment Syndrome [2,3]. The sequential measurement time was determined as every six hours [8,9] , at the 6th, 12th, 18th, and 24th hours.

Routine Anesthesia Procedure

In patients undergoing general anesthesia, anesthesia was induced with 1-2 µ/kg fentanyl (Talinat, Vem Pharmaceuticals, Turkey), 2mg/kg propofol (Propofol Fresenius Vial, Germany), and 0.6 mg/kg rocuronium (Myokron, Vem Pharmaceuticals, Turkey) intravenously. After the patients were intubated endotracheally, ventilation was provided with an anesthesia device (Drager Primus, Germany). All patients underwent decompression by inserting a 14 Fr nasogastric tube before surgery. At the end of the surgery, patients with stable hemodynamics and adequate respiratory effort were extubated in the operating room. Patients who could not be extubated were transferred to the intensive care unit intubated.

After providing aseptic conditions in the sitting position for spinal anesthesia, 10-15 mg of heavy bupivacaine (0.5%) was administered with a 25-gauge spinal needle in the lumbar 3-4 or 4-5 interspaces. Patients were sedated by intravenous administration of 0.05-0.1 mg/kg midazolam (Zolamid, Vem Pharmaceuticals, Turkey) to achieve a Ramsey sedation scale of 3-4.

Routine Surgical Procedure

In patients who underwent open surgery, the abdomen was opened with a median incision under general anesthesia and an aortobifemoral or aortoiliac 16x8 Dacron Y graft was placed in all patients after aneurysmectomy. The retroperitoneum was closed with 3/0 vicryl in all patients who underwent open surgery. In some patients who underwent open surgery, before the abdomen was closed, a chest drain was placed above

Figure 1. Unometer abdo-pressure intraabdominal pressure monitoring

the retroperitoneum when deemed necessary. In patients to be treated with the EVAR procedure, spinal anesthesia and sedation were performed. In the EVAR procedure, after preparation of both femoral arteries, the grafts were inserted into the aneurysm sac, in the infrarenal aorta in the main trunk, and in the contralateral iliac leg. All patients were transferred to the intensive care unit after the procedures were complete.

Statistical Method

SPSS 21.0 (Statistic Inc. version Chicago, IL, USA) software program was used for the statistical analysis of the data. Descriptive statistics were presented as mean ± standard deviation for continuous variables, and the number of patients (%) for nominal variables. Results were considered statistically significant when they were at 95% confidence intervals and when p<0.05.

Results

A total of 36 patients underwent surgery and EVAR procedure for intact infrarenal abdominal aortic aneurysm between June 2018 and September 2021. Eleven patients underwent open surgery without drains (Group 1), eleven underwent open surgery and a drain (Group 2), and 14 patients underwent EVAR (Group 3). Among all, 77.78% (n=28) were males and 22.22% (n=8) were females (p<0.05). The genders did not significantly differ in intergroup comparisons (p>0.05) (Table 1). The mean age of the patients in Groups 1, 2, and 3 were 65.27 ± 3.98 years, 64.54 ± 4.18 years, and 64.79 ± 4.64 years, respectively (p>0.05) (Table 1). The demographic data and comorbidities of the groups are summarized in Table 1.

Table 1. Demographic data and comorbidities of the groups

	Group 1	Group 2	Group 3	P *
Age (years) (mean ± SD)	65.27 ± 3.98	64.54 ± 4.18	64.79 ± 4.64	0.922
Male n (%)	8 (72.73)	9 (81.82)	11 (78.57)	0.924
Women n (%)	3 (27.27)	2 (18.18)	3 (21.43)	0.924
Height (cm) (mean ± SD)	172.27 ± 9.08	172.45 ± 8.91	172.14 ± 8.84	0.996
Weight (kg) (mean ± SD)	80.45 ± 9.66	79.36 ± 8.13	80.86 ± 8.24	0.910
Aneurysm Diameter (cm) (mean ± SD)	5.87 ± 0.27	5.91 ± 0.25	6.01 ± 0.28	0.400
ASA 3 n (%)	7 (63.64)	8 (72.73)	10 (71.43)	0.709
ASA 4 n (%)	4 (36.36)	3 (27.27)	4 (28.57)	0.709
Ejection Fraction (mean ± SD)	49.54 ± 6.10	50.91 ± 5.84	51.07 ± 5.94	0.796
Coronary Artery Disease n (%)	1 (9.09)	1 (9.09)	2 (14.29)	0,890
Diabetes Mellitus n (%)	2 (18.18)	3 (27.27)	3 (21.43)	0,873
Hypertension n (%)	3 (27.27)	4 (36.36)	5 (35.71)	0,877
COPD n (%)	2 (18.18)	1 (9.09)	2 (14.29)	0,826
Smoking n (%)	4 (36.36)	3 (27.27)	5 (35.71)	0,877

P<0.05: Significance level, SD: Standard deviation, n: Number, ASA: American Society of Anesthesiologists, COPD: Chronic Obstructive pulmonary disease.

Table 2. Comparison of preoperative and postoperative mean IAP measurement values between groups

	Group 1	Group 2	Group 3	P *
Preoperative IAP (mean ± SD)	4.81 ± 0.98	5.09 ± 0.94	5.16 ± 0.86	0.663
Postoperative 6th hour IAP (mean ± SD)	8.82 ± 1.08	8.63 ± 1.02	7.93 ± 0.99	0.086
Postoperative 12th hour IAP (mmHg) (mean ± SD)	15.27 ± 1.01	14.91 ± 0.94	8.14 ± 1.03	<0.000
Postoperative 18th hour IAP (mmHg) (mean ± SD)	14.36 ± 1.12	13.09 ± 1.04	7.57 ± 1.02	<0.000
Postoperative 24th hour IAP (mmHg) (mean ± SD)	12.09 ± 0.83	10.09 ± 1.22	6.43 ± 1.16	<0.000

P<0. 05: Significance level, SD: Standard deviation, IAP: Intraabdominal pressure.

Preoperative and postoperative IAP measurements of the groups are indicated in Table 2. IAP measurement was lower in the group that underwent the EVAR procedure (Group 3) compared to the other groups at each measurement time. This difference was significant, especially at 12, 18, and 24 hours (p<0.05) (Table 2).

The IAP values in Group 2 were insignificantly lower in the postoperative period than in Group 1 (p>0.05). The IAP value of 20 mmHg, the limit for ACS, was not exceeded at any time in any of the groups (Table 2).

The groups were also compared in terms of postoperative complications and mortality. Respectively, neurological complications were seen in 1 (9.09%) patient in Group 1 and in 1 (9.09%) patient in Group 2, it was not detected in Group 3. Infection was detected in 1 (9.09%) patients in group 1, 2 patients (18.18%) in group 2, and 2 (14.29%) patients in group 3. Bleeding was detected in 1 (9.09%) patient in Group 1, in 3 (27.27%) patients in Group 2, and 2 (14.29%) patients in Group 3. Mortality was detected in 1 (9.09%) patient in Group 1.

Discussion

An abdominal aortic aneurysm is a life-threatening disease characterized by the enlargement of the abdominal aorta. Although it is usually asymptomatic, it has a high mortality rate in case of rupture. Hypertension, smoking, advanced age, and male gender are stated among the risk factors for atherosclerosis [10,11]. Our study patients were also older and had a higher male sex ratio with comorbidities such as hypertension, smoking, and coronary artery disease, which developed because of atherosclerosis.

Endovascular procedure and open surgical repair are treatment methods for abdominal aortic aneurysms [12]. Increased IAP and abdominal compartment syndrome are serious complications that can develop after both an endovascular procedure and open surgical repair. It can be successfully treated with early diagnosis, early conservative treatment to reduce intra-abdominal pressure, and decompression laparotomy if compartment syndrome develops [5].

The guideline published by the World Society of the Abdominal Compartment Syndrome suggests that IAP should be measured through the bladder [2,3]. IAP increase was also defined and classified by the World Society of the Abdominal Compartment Syndrome, with a grade 1 increase indicating an IAP of 12-15 mmHg, a grade 2 increase, an IAP of 16-20 mmHg, a grade 3 increase, an IAP of 21-25 mmHg, and a grade 4 indicating an IAP of >25 mmHg [3,4].

In our clinic, IAP is also measured through the bladder, per the guideline. In our study, the level of IAP increase was grade 1 at 12t, 18t, and 24 hours postoperatively in Group 1, and at 12 and 18 hours postoperatively in Group 2. In Group 3, an IAP increase was not observed at all postoperatively (Table 2). Therefore, the increase in IAP did not exceed grade 1 in any of our groups. In Group 3 patients, who underwent endovascular repair, IAP remained at a normal level at all postoperative measurement times.

In ACS, organ dysfunction develops after significant IAH. The intrathoracic pressure that develops when the diaphragm is pushed cephalad compresses the heart and reduces ventricular compliance and contractility. In addition, reduced venous return decreases cardiac output, which all create cardiac dysfunction [4,13] . Increased intrathoracic pressure also negatively affects the pulmonary system. Alveolar volutrauma occurs when intrathoracic pressure increases, ventilation-perfusion mismatch occurs with increased peak airway pressure, and pulmonary compliance decreases. Total lung capacity and functional residual capacity are limited. Therefore, ventilation decreases due to decreased tidal volume and ventilation failure occurs [4,13]. Decreased renal blood flow and compression of the renal artery, vein, and parenchyma are among the crucial factors contributing to renal dysfunction, which causes a decrease in urine output [4,13]. Developing vascular pathologies lead to the compression of the inferior vena cava and increased systemic vascular pressure, resulting in an increased risk of venous thrombosis, peripheral edema, and venous stasis [4,13]. In cases where the IAP value exceeds 25 mmHg, a laparotomy is recommended for decompression [14].

Rubenstein et al. investigated the relationship between open surgical repair and endovascular repair and ACS in patients diagnosed with a ruptured abdominal aortic aneurysm and found that ACS developed in 6 (21%) of 29 patients who underwent EVAR and 15 (34%) of 44 patients who underwent open repair [5]. In a study on 6612 patients conducted by Ersyrd et al., open surgery and endovascular procedure were performed for abdominal aortic aneurysms and their relationship with ACS was investigated [6]. The study population consisted of 1341 patients (20.3%) with ruptured abdominal aortic aneurysms and 5271 patients (79.7%) with intact abdominal aortic aneurysms. They reported that ACS developed more frequently in patients diagnosed with ruptured abdominal aortic aneurysms. Patients in both groups were also compared in terms of ACS development according to the procedure. The rate of ACS development in patients who underwent open surgery due to ruptured aortic aneurysms was 6.8%, while it was 6.9% in patients who underwent EVAR, and in patients with intact aortic aneurysms, the rate of ACS development was 1.6% in those who underwent open surgery and 0.5% in those who underwent EVAR [6]. In the literature, information has taken its place that significantly less ACS develops in EVAR in intact abdominal aortic aneurysms. In our study, ACS did not develop in any of our patients. However, while the cases in our study were treated due to intact abdominal aortic aneurysm, the cases in the study by Rubenstein et al. had ruptured abdominal aortic syndrome. We think that this is the reason for the development of ACS in the cases of Rubenstein et al. In our study, although ACS did not develop in any of our patients, intra-abdominal pressure values were lower in our patients who underwent the EVAR procedure than in patients who underwent open surgery .

The limitations of our study include the small number of patients compared to the study by Rubenstein et al. and its retrospective nature.

Conclusion

Abdominal aortic surgery and endovascular procedures are two of the main subjects of cardiovascular surgery clinics. We observed that abdominal closure by placing a drain in patients who underwent open surgery for the abdominal aorta is more reliable in terms of IAP values, although not statistically significant. Patients undergoing endovascular treatment for aneurysms are statistically less at risk for increased IAP. We believe that the IAP values, which can be easily obtained non-invasively via the catheter inserted into the bladder, will help surgeons to monitor pressure changes promptly before abdominal compartment syndrome and related organ dysfunctions develop.

Considering the findings that EVAR procedures are safer in terms of IAP increase, we think this treatment method should be preferred, especially in risky patients.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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