ORIGINAL ARTICLE

THE VARIATION OF INTRAOCULAR PRESSURE IN THE CONTEXT OF ABDOMINAL SURGERY

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Abstract

The human body can be envisioned as a high-performance machine that operates on the principle of "gears". As a consequence, any disorder at a certain level might lead to imbalances in other areas, which are sometimes difficult to detect and measure. One such relationship between two seemingly unrelated systems is that of abdominal surgery and intraocular pressure. The literature on this subject is poor, but available research suggests the occurrence of a change in intraocular pressure in the context of abdominal surgery. The present study analyzed the variation of intraocular pressure for two groups of patients who underwent classical or laparoscopic cholecystectomy. The present research is based on a prospective, non-interventional, observational, descriptive study, carried out in the III^rd^ General Surgery Clinic of the University Emergency Hospital, Bucharest. The study included patients who underwent abdominal surgery during January 2018 - December 2019. The study gathered a total of 67 patients, separated into two groups: 52 patients who underwent laparoscopic cholecystectomy and 15 who underwent open cholecystectomy. No definite relationship between intra-abdominal pressure and intraocular pressure was found in the analyzed group, probably due to the small sample size, but further research is encouraged.

Keywords: *intraocular pressure, classical cholecystectomy, laparoscopic cholecystectomy, anesthesia, abdominal surgery*

Introduction

The human body is a high-performance machine that operates on the principle of "gears". This means that any disorder at a certain level will lead to imbalances in other areas, even if they are difficult to detect and measure. One such relationship between two seemingly unrelated systems is that of abdominal surgery and intraocular pressure. There are not many available data in the literature on this topic, but the existing ones confirm the occurrence of intraoperative IOP changes in patients undergoing abdominal surgery. The present study analyzed the variation of intraocular pressure for a group of patients who underwent cholecystectomy either laparoscopically or classically. We consider necessary to study this phenomenon and to identify a possible determinism between surgical treatment of abdominal pathologies and intraocular hypertension syndrome. Intraocular pressure is the pressure of the fluid inside the eye reflecting the balance between the production and resorption of aqueous humor. It provides the internal components of the eyeball with the conditions necessary for optimal functioning. The value of this parameter is not constant over time but varies with both the circadian cycle and other intrinsic and extrinsic parameters. Normal values are in the range of 10-21 mmHg with a maximum in the morning and a minimum in the evening. Therefore, the intraocular pressure varies between certain physiological limits, which, if exceeded, have repercussions on the optical apparatus and on the ocular metabolism, disturbing the normal functioning of vision. The balance between active production and the elimination of aqueous humor, is translated by the concept of intraocular pressure (IOP). Intraocular hypertension (IOH) is an increase in IOP above the normal upper limit of 21 mmHg, in one or both eyes, measured at one or more medical visits, in the absence of optic nerve or visual field changes. IOH gives the patient the status of a glaucoma suspect [1].

Materials and Methods

The present research is based on a prospective, non-interventional, observational, descriptive study, carried out in the III[rd] General Surgery Clinic of the University Emergency Hospital, Bucharest. The study included patients who underwent abdominal surgery during January 2018 - December 2019.

Confidentiality and ethics requirements were met. The study was conducted in accordance with the Helsinki Declaration and European Union legislation.

The selection of patients for introduction in the study was made on the basis of meeting all inclusion criteria and none of the exclusion criteria. The study gathered a total of 67 patients diagnosed with acute cholecystitis, which were separated into two groups: group 1 -52 patients underwent laparoscopic cholecystectomy and group 2- 15 underwent open cholecystectomy.

Patients over the age of 18 years, who agreed to participate in the study and who had the admission diagnosis of acute calculous cholecystitis were included in the study. Patients were excluded if they lacked the proper disease documentation, if they had pre-existing ocular pathology, an ASA score above 3 and if they did not provide informed consent or if they refused to participate in the research. Patients in whom the surgical intervention was of absolute urgency were also excluded.

The IOP was measured in all 67 patients in different moments, as follows: 1 hour preoperatively (IOP 1), 5 minutes preoperatively on the operating table (IOP 2), during anesthetic induction and oro-tracheal intubation (IOP 3), 10 minutes after IOP 3 (IOP 4 which corresponded in group 1 to insufflation of the peritoneal cavity with CO2 and in group 2 with opening of the peritoneal cavity), at the time of anti-Trendelenburg patient positioning (IOP 5), at the end of the surgery, during skin suturing (IOP 6), during extubation (IOP 7), 1 hour postoperatively (IOP 8).

The IOP was measured by using the Maklakov tonometer. The obtained values were noted for each patient and analyzed using Microsoft Excel.

Results

Acute cholecystitis – laparoscopic approach

There were 52 patients diagnosed with acute cholecystitis who underwent laparoscopic cholecystectomy. The age in this group of patients varied between 56-88 years, with an average of 73.48 years, a median of 75 years and a standard deviation of 8.89. The gender distribution of the same group showed a higher incidence in males (57.7%, 30 men), compared to females, representing 42.3% of cases (22 women).

The recorded values for body mass index (BMI) ranged between 19 and 30, with an arithmetic mean of 24.28, a median of 24, and a standard deviation of 2.22.

In the group of laparoscopically cholecystectomized patients, the operative time varied from 62 minutes to 115 minutes, with a mean value of 85.11 minutes, a median of 86 minutes, and a standard deviation of 11.

The type of anesthesia used in the group of patients with laparoscopic cholecystectomy is general anesthesia with orotracheal intubation. In order to induce anesthesia, two different compounds were used, Sevoflurane and Propofol. A number of 42 patients, representing 80.8% of the study group, received anesthesia with Sevoflurane and a number of 10 patients (19.2%) received anesthesia with Propofol (Figure 1).

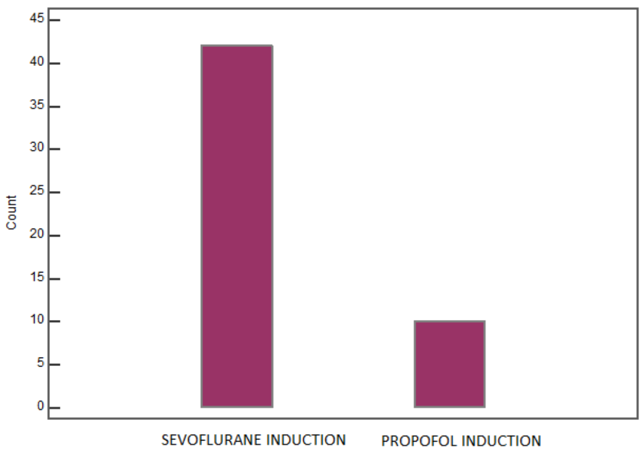

Figure 1 – Distribution of patients who underwent laparoscopic cholecystectomy according to the substance utilized for anesthesia induction

IOP	N	Mean	SD	Median	Minimum	Maximum
IOP1_RE	52	15.135	1.3724	15.000	13.000	18.000
IOP1_LE	52	15.173	1.3243	15.000	13.000	18.000
IOP2_RE	52	15.308	1.2294	15.000	13.000	18.000
IOP2_LE	52	15.288	1.3036	15.000	13.000	18.000
IOP3_RE	52	17.192	1.2531	17.000	15.000	20.000
IOP3_LE	52	17.385	1.4024	17.000	15.000	20.000
IOP4_RE	52	18.385	1.4573	18.500	16.000	21.000
IOP4_LE	52	18.731	1.7835	18.500	16.000	22.000
IOP5_RE	52	18.269	1.5096	18.000	15.000	21.000
IOP5_LE	52	18.538	1.7429	18.000	16.000	22.000
IOP6_RE	52	17.981	1.5274	18.000	15.000	21.000
IOP6_LE	52	18.154	1.8299	18.000	16.000	22.000
IOP7_RE	52	19.442	1.6967	19.500	16.000	22.000
IOP7_LE	52	19.731	1.9715	19.500	16.000	23.000
IOP8_RE	52	15.500	1.0572	15.000	14.000	18.000
IOP8_LE	52	15.635	1.2990	15.500	13.000	19.000
	N	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**
IOPdelta	52	4.981	1.8733	5.000	1.000	9.000
IOPmax	52	19.904	1.9226	20.000	16.000	23.000
IOPmin	52	14.923	1.2962	15.000	13.000	18.000

Table 1 – IOP variation in the group of patients who underwent laparoscopic cholecystectomies. IOP= intraocular pressure, RE=right eye, LE=left eye, IOP1=preoperative values recorded in the patient room, IOP2= preoperative values recorded preoperative with the patient on the operating table, IOP3= values recorded during anesthetic induction and oro-tracheal intubation, IOP4= values recorded during insufflation of the peritoneal cavity with CO2, IOP5= values recorded at the time of anti-Trendelenburg patient positioning, IOP6= values recorded at the end of the surgery, during skin suturing, IOP7= values recorded during extubation, IOP8= values recorded postoperatively, IOPmax= the maximum value recorded, IOPmin= the minimum value recorded, IOPdelta= the IOP increase during the surgical intervention

Figure 2 and Table 1 highlight the variation of pre-, intra- and postoperative IOP in laparoscopically cholecystectomized patients. There is an increase in IOP during anesthetic induction and oro-tracheal intubation (IOP 3), reaching a maximum value of 20 mmHg, compared with the preoperative values recorded in the patient room (IOP 1), respectively immediately preoperative, on the operating table (IOP 2). IOP 1 and IOP 2 values ranged from 13 to 18 mmHg. The evaluation of IOP 4, which corresponds to the moment of the peritoneal cavity insufflation with CO2, registered an increase of up to 22 mmHg. At the time of anti-Trendelenburg patient positioning (IOP 5), IOP values ranged from 15 to 22 mmHg.

After abdominal cavity exsufflation, the skin suture corresponds, in our research, to IOP 6 moment. The evaluation of this parameter highlighted values between 15 and 22 mmHg. The highest value of IOP in the group of laparoscopically cholecystectomized patients was recorded during extubation - IOP 7, namely 23 mmHg. Postoperatively (IOP 8), we observed a decrease in IOP to values similar to those assessed preoperatively (IOP 1), between 13 and 18 mmHg.

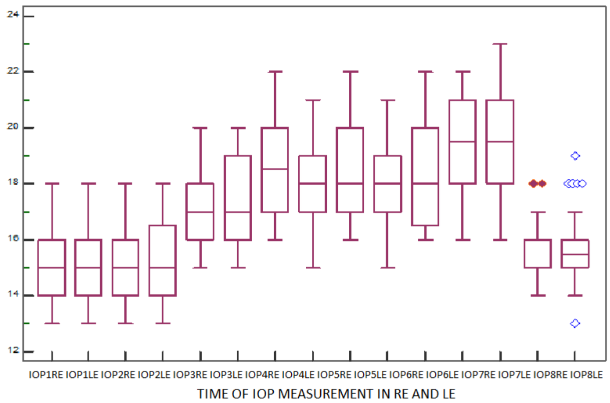

Figure 2 – IOP variation pre-, intra- and postoperative in patients who underwent laparoscopic cholecystectomy. IOP= intraocular pressure; RE= right eye; LE= left eye

Acute cholecystitis – classic approach

The second studied group comprised 15 patients who underwent open cholecystectomies. The age of this group of patients was between 68 and 85 years, with an average of 76.93, a median of 79 years and a standard deviation of 6.05. The analysis of the sex distribution in open cholecystectomies group showed a higher percentage of males - 60% (9 men), compared to females -40% (6 women).

In the analyzed sample, the BMI registered a minimum value of 19, which represents a normal weight, and a maximum value of 30, identified in only one patient who had grade 1 obesity. The average in this group is 24.2 which signifies a normal weight, with a median of 24 and a standard deviation of 2.62.

In the sample of patients who underwent open cholecystectomy, the operating time recorded values in the range of 74 - 110 minutes, with an average value of 93.26 minutes, a median of 95 minutes and a standard deviation of 9.64.

After analyzing the intraoperative blood pressure (BP) values recorded in this group, a minimum BP value of 90 mmHg, a maximum value of 130 mmHg, with an average of 116 mmHg and a median of 120 mmHg were noted. The maximum BP recorded values in the range of 120-160 mmHg, with an average value of 144.66 mmHg and a median of 140 mmHg.

The type of anesthesia utilized was general anesthesia with orotracheal intubation, similar to patients undergoing laparoscopic procedure. For its induction, a number of 12 patients received Sevoflurane, representing a percentage of 80%, and the remaining 3 patients received Propofol (Figure 3).

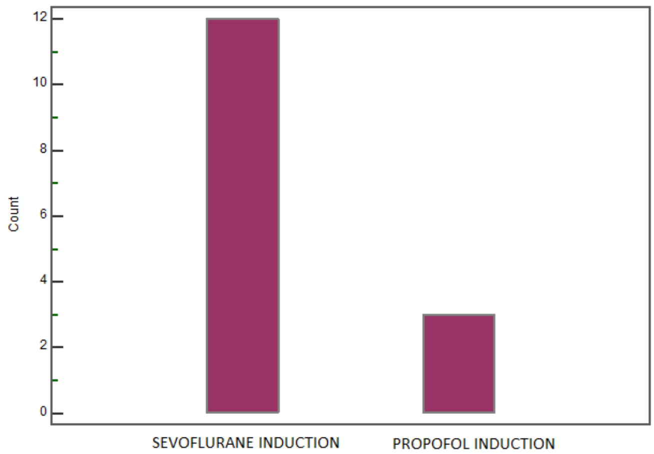

Figure 3 – Patient distribution according to the anesthetic substance used in the group of open cholecystectomies

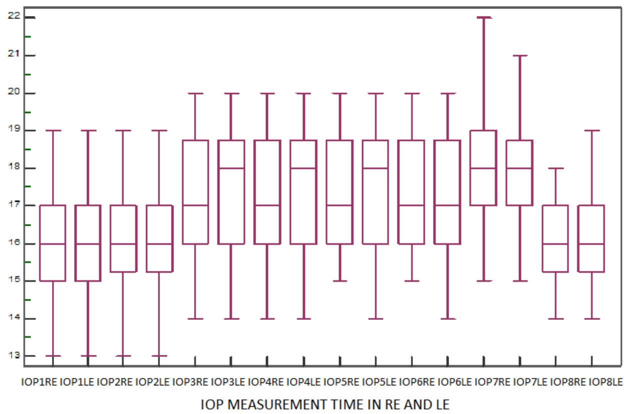

Figure 4 – Patient distribution according to IOP in the group of open cholecystectomies. IOP= intraocular pressure; RE= right eye; LE= left eye

Open cholecystectomies versus laparoscopic cholecystectomies

Comparative analysis from the perspective of intraocular pressure of the open and laparoscopically cholecystectomized patients, revealed that IOP values in laparoscopically cholecystectomized patients are higher than those of open cholecystectomized, with a maximum of 22 mmHg after 30 minutes intraoperatively (IOP 5) (Figure 5).

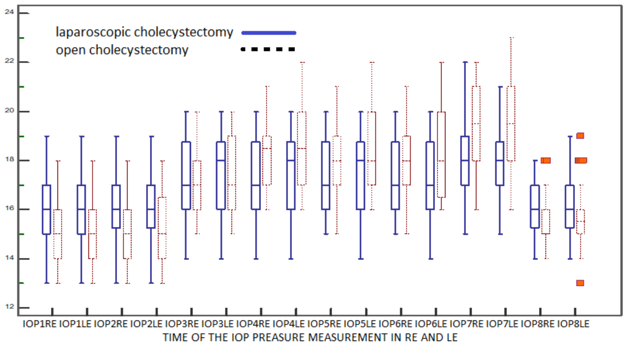

Figure 5 – Comparative distribution of IOP in patients who underwent laparoscopic cholecystectomy versus patients who underwent open cholecystectomies. IOP= intraocular pressure; RE= right eye; LE= left eye

The operating time was notably higher for patients undergoing open cholecystectomy, as this approach is preferable for complicated of acute cholecystitis.

No correlation was identified between the operating time and the maximum variation recorded in IOP (Pearson correlation r = -0.08).

Discussion

The mechanisms by which intraocular hypertension occurs are not well known. What is certain is that there is an imbalance between the production of aqueous humor, a liquid that occurs permanently in the eyes, and its elimination. Aqueous humor is constantly eliminated and any decrease in the rate of this process or any increase in production can overwhelm with this delicate equilibrium leading to an intraocular accumulation and consequently an increase in intraocular pressure [1].

Intra-abdominal pressure (IAP) is defined as the pressure resulting from the interaction of the viscera with the abdominal wall. This parameter varies depending on the respiratory phases, the resistance of the abdominal wall, and on also the body mass index (BMI) and position. The IAP measurement is done at the end of the expiration phase, in supine position. Recent studies highlight the close link between IAP and IOP, an increase in IAP causing an increase in IOP, especially in laparoscopic surgery, when IAP after insufflation of the abdominal cavity with CO_2 reaches values of 12mmHg [2]. In these circumstances, we consider legitimate the question whether, in addition to the pathophysiological implications of IAP on IOP, there are also practical applications deriving from this link, namely IAP estimation using IOP measurement, as IOP measurement is much easier and more accessible.

A number of recent studies have shown an increase in intraocular pressure during abdominal surgery, especially laparoscopic surgery with insufflation of the peritoneal cavity. Other studies have highlighted the involvement of the patient's position during surgery in the development of intraocular hypertension - Trendelenburg compared to reverse Trendelenburg - as well as the prolonged surgical length [3]. We consider that if this risk is high, then it is preferable to administer a treatment even in the stage of intraocular hypertension, to avoid complications. When the optic nerve undergoes changes, they are irreversible. Impairment of the visual field along with changes in the optic nerve, translates the notion of glaucoma, where IOP is the key element.

The type of anesthesia, various perianesthetic aspects as well as the anesthetic used are directly involved in the acute closure of the chamber angle with intraocular hypertension phenomena. However, this pathological entity is relatively rare, but can have severe consequences on the visual prognosis, if a correct treatment is not administered immediately [3]. Although most anesthetics are associated with intraocular hypotension, there are a number of factors that lead to increased perianesthetic IOP: endotracheal intubation, detubation, hypoxia, hypertensive flare-up, mydriasis.

Mydriasis is by far the most important factor involved in the pathogenesis of increased intraocular pressure during surgery under general anesthesia. Mydriasis directly closes the chamber angle, thus blocking the drainage of aqueous humor through the trabecular meshwork, which leads to an acute increase in intraocular pressure. Another condition that leads to exacerbation of mydriasis during surgery under general anesthesia is low light. Certain surgeries, in this case laparoscopic surgeries are performed in a dark room, thus helping to maintain mydriasis initiated by anesthesia. Literature describes cases of acute attack of glaucoma produced by closing the chamber angle produced at night, in intensive care units, in a dark room. The administration of a parasympatholytic or sympathomimetic medication such as phenylephrine or ephedrine (which is administered in case of blood pressure collapse, a relatively common situation in abdominal surgery), is associated with the induction of mydriasis [4]. The physical and mental stress felt by the patient, which usually accompanies any surgery, produces mydriasis by activating the sympathetic nervous system acting on the dilator muscle (radius) of the pupil [5].

It is a well-known fact that airway manipulation is associated with increased IOT, due to an increase in blood pressure, which leads to increased ocular blood flow. The vast majority of studies show a marked increase in IOT during intubation. In contrast, recent studies also pay special attention to the detubation maneuver, which is less studied from the perspective of IOT growth and reveals a higher increase compared to intubation. Glaucomatous patients have higher IOT increases compared to non-glaucomatous patients on both intubation and extubation and are more prone to eye damage. Deep anesthesia can reduce IOT by up to 15 mmHg. Detubation during deep anesthesia may prevent TIO increases in glaucomatous patients. The risks of deep anesthesia are well known and include upper airway obstruction, laryngospasm, and pulmonary aspiration. There are, however, reports that suggest that detubation of the awake patient does not produce a substantially different hemodynamic response than extubation under deep anesthesia. However, coughing that occurs during conscious detubation can cause increases in IOT of more than 50 mmHg and should be avoided in glaucomatous patients [6,7].

Conclusion

Our study showed an increase in intraocular pressure during abdominal surgery. The increase was more important in the case of laparoscopic interventions where there is a higher intra-abdominal pressure. Although the increase has no clinical implications in healthy patients, it could lead to an exacerbation of a pre-existing ocular pathology, therefore, we consider that further research is needed.

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