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Original article

MONITORING OF INTRA-OCULAR PRESSURE (IOP) DURING LAPAROSCOPIC VS. LAPAROTOMIC SURGERY IN CHILDREN.

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A B S T R A C T

The aim of our study was to evaluate the changes of IOP during laparoscopic surgery in pediatric patients.We enrolled thirty-six patients, ranging in-between 15 months-16 years, undergoing elective abdominal surgery. Eighteen received laparoscopic surgery (LS) and eighteenlaparotomy surgery (LT). In the LS group, IOP was measured before and after induction, during mechanical ventilation, after established pneumoperitoneum, in the Trendelenburg position after 5, 10 and 30 min (T5, T10, T30), and at extubation time. In the LT group IOP was measured before and after induction, during surgical incision, after 5, 10, 30 min and at extubation time in supine position.Compared to LT group, where IOP (baseline: 10.9±1.7 mmHg) was unchanged during the whole procedure, in the LS group(baseline: 10.8±2.4 mmHg),IOP increased significantlyafter established pneumoperitoneum and during Trendelenburg positioning (maximal mean value at T5: 14.6±2.1 mmHg).In pediatric patients that receive laparoscopic surgery, IOP increases by some mmHg.

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1. Introduction

Laparoscopic techniques have improved the outcome of abdominal surgery. The advantages over the traditional “open” surgical approach include the avoidance of large incisions, less fluid loss, minimal heat loss, less pain and reduced stretching of body tissues. Besides - the general improvement in the quality of life, in paediatric surgery, the laparoscopic procedure allows an earlier return to normal activities, reducing the expense of child care and time off work for the parents [1].

In order to allow intra-abdominal surgical manipulation, laparoscopic surgery requires the introduction of a carbon dioxide pneumoperitoneum and an appropriate positioning of the body. In this situation, increased intrabdominal pressure (by pneumoperitoneum and the Trendelenburg position) could affect intraocular pressure (IOP) by increasing the episcleral vein pressure. Previous studies in adults showed an increase in IOP during laparoscopic surgery and suggested that significant IOP could occur in glaucomatous eyes [2, 3].

The aim of this study was to evaluate the changes in IOP occurring during laparoscopic surgery in pediatric patients without previous eye disease.

2. Material and methods

The study was performed at the Policlinico Rodolico of the University of Catania, Catania, Italy.

The study followed the tenets of the Declaration of Helsinki and was approved by the Hospital Medical Ethics Committee; an informed consent was obtained from the parents after the aim and the possible risks of the study had been fully explained.

Consecutive patients undergoing elective abdominal surgery were included in the study. All aged less than 18 years, were scheduled for elective laparoscopic or open laparotomy, the choice was made by the surgical team, ASA physical status I and II; children with a cardiovascular or respiratory disease, any ocular pathology or previous surgery, and children receiving medication known to alter IOP were excluded from the study.

All patients received a preoperative ophthalmologic clinical examination 1 days before surgery (anterior segment biomicroscopy and fundus examination).

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Anaesthesiological procedures included EMLA cream on the expected site of venipunctureand a premedication with 0.5 $mg \cdot kg^{-1}$ of oral midazolam (maximum dose 5 mg), 30 min before surgery. Fluid administration (saline solution) was standardized at 4 $ml \cdot kg^{-1} \cdot h^{-1}$ for children with a body weight less of 10 Kg, 40 ml + 2 $ml \cdot kg^{-1} \cdot h^{-1}$ for each Kg over 10 kg, 60 ml + 1 $ml \cdot kg^{-1} \cdot h^{-1}$ for each Kg over 20 kg. In both groups, an inhalational induction of anesthesia was performed using 8% sevoflurane in a mixture of oxygen and air via face mask and an intra venous line was established and fentanyl 1-2 $\mu g \cdot Kg^{-1}$ and rocuronium 0.4 $mg \cdot Kg^{-1}$ for oro-tracheal intubation(4) were administered [4]. Anaesthesia was maintained with a FiO_2 50% and sevoflurane (1 MAC). Boluses of fentanyl 1-2 $\mu g \cdot Kg^{-1}$ were administered every 15-20 min according to heart rate and blood pressure. Mechanically controlled ventilation with a tidal volume of 6-10 $ml \cdot Kg^{-1}$ was adjusted to maintain an endtidal CO2 of 38-40 mmHg. Patients in the LS group were operated in the Trendelenburg position at 10 degrees, after carbon dioxide insufflation (pneumoperitoneum); Intra Abdominal Pressure (IAP) was always maintained below 15 mmHg (Therm-Pneu electronic; WISAP America Inc., Lenexa, KS, USA). At the end of surgery, the pneumoperitoneum was evacuated and patients were placed in the supine position. Patients of the LT group were operated in supine position.

Patient characteristics such as age, weight, hemodynamic data [heart rate (HR), non invasive blood pressure (NIBP)] and respiratory parameters (pulse-oximetry, fractional inspiratory oxygen concentration (FiO2), respiratory rate (RR), peak inspiratory pressure (PIP), positive end-expiratory pressure (PEEP) were recorded by bedside monitoring and respirator. In the LS group we also recorded the Intra Abdominal Pressure (IAP).

The measurement of the Intra Ocular Pressure (IOP) in the LS group was done in the supine position before induction of anesthesia, after induction during mechanical ventilation, at 5, 10, and 30 min, after pneumoperitoneum introduction in the Trendelenburg position; in the supine position after evacuation of pneumoperitoneum, and at extubation time.

In the LT group, all measurements of IOP were performed in the supine position; the parameters were measured before induction, after induction of anesthesia, during mechanical ventilation, at the surgical incision, after 5, 10, and 30 min, at the end of the surgery, and atextubation time.

IOP was measured by an ophthalmologist in one eye (randomly chosen at the beginning of the study) by a Perkins applanation tonometer and a wire lid speculum. Before induction, oxybuprocaine 0.4% eye drops were used as topical anesthetic for IOP measurement, while topical tobramycin 0.3% eye drops were applied during surgery before measurement.

The sample size (at least 12 patients for each group) was determined from the results of a previous study and our pilot data to detect a 3 mmHg difference in IOP with an alpha of 0.05 and 90% power (two-tailed) [3]. In each group, the values of each parameter recorded during the experiment were compared by ANOVA; if significant multiple comparisons were performed by the Tukey-Kramer test, non-paired t-test was used for comparison between the two groups with $P<0.05$ considered as statistically significant. Data are presented as mean (±SD).

3. Results

We included in the study 36 patients, aged from 15 months to 16 years; 18 received an elective laparoscopic abdominal surgery (7 appendectomy, 6 orchidopexies, 5 varicocelectomy) and 18 an elective open laparotomy (8 appendectomy, 6 orchidopexies, 4 varicocelectomy).Mean age ± (SD) in LP group is 7.3 ±4.6 years and in LT group is 7,6±4.2. During surgery, no significant changes were seen in BP, HR, SpO_2, PAP and IAP. (Table 1). $EtCO_2$ did not change in the LT group(ANOVA ns), while in the LS group it increased significantly during maintenance of anesthesia ($P<0.001$), remained higher than baseline throughout the period of pneumoperitoneum, then decreased at the end of surgery.

Baseline IOP was 13.2±1.1 mmHg in the LS group and 13.3±1.4 mmHg in the LT group. During induction IOP decreased in both groups. In the LT group there was no significant difference between the baseline value (IOP: 10.9±1.7 mmHg) and the values detected during mechanical ventilation. In the LS group (baseline IOP: 10.8±2.4 mmHg) IOP increased significantly after pneumoperitoneum introduction and in the Trendelenburg position (13.1±2.5 mmHg and 14.6±2.1 mmHg respectively) ($P<0.01$), decreased in the supine position and after pneumoperitoneum evacuation (11.7±1.7 mmHg), and returned to pre-induction values (12.5±1.4 mmHg) after extubation (Figure 1).

	Laparoscopic		Laparotomic		P value
	Mean	SD	Mean	SD	
Age (years)	7.3	4.6	7,6	4.2	NS
Genre (M/F)	10/8		12/6		NS
Weight (Kg)	28.3	18.7	30.5	17.7	NS
Systolic Blood pressure (mmHg)	97.8	7.8	99.2	8.5	NS
Diastolic Blood pressure (mmHg)	52.7	11	54.8	10.1	NS
Heart rate (bpm)	109.2	20.3	105.5	19.5	NS
SpO_2 (%)	99.6	0.5	99.4	0.4	NS
ASA (I/II)	15/3		14/4		NS
PAP (cmH_2O)	14.9	3.6	13.9	3.5	NS

Table 1 - Data are expressed as mean ± standard deviation (SD) or number; ASA = American Society of Anesthesiologists

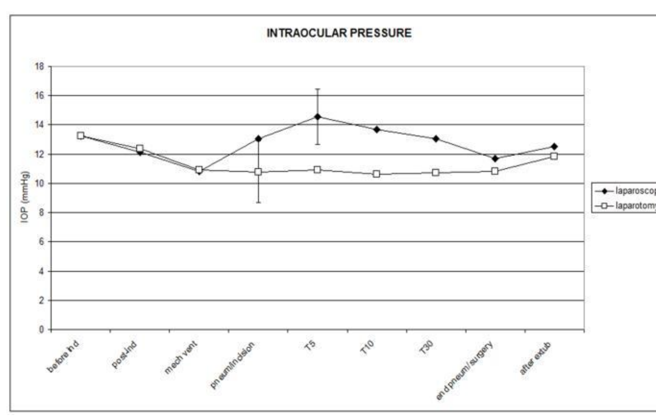

Figure 1 - Intraocular pressure (IOP) in patients (n=36) undergoing non-ophthalmic surgery anesthesia. Data are mean and SD. *P<0.001, °P<0.01.

In LS group, maximal IOP value was detected at T 5 in the Trendelenburg position with pneumoperitoneum, and, from the mean value detected after induction during mechanical ventilation (10.8±2.4 mmHg), the overall mean IOP increase was 3.8±1.8 mmHg (38±21.4 %)(+2.3 ±1.9 mmHg after pneumoperitoneum introduction, and a further IOP increase of 1.5 ±2 at T 5). In one patient had an IOP increase of 6 mmHg in one eye and 7 in the other (IOP was 20 mmHg in both eyes).

A significant difference (t-test $P \leq 0.01$) in the IOP between groups was found after establishing pneumoperitoneum and at T5, T10, T30 (Table 2). No correlation was found between EtCO2 and IOP.

INTRAOCULAR PRESSURE										
		beforeind	post-ind	mechvent	pneum	T 5	T 10	T 30	post pneumesuff	afterextub
laparoscopy	mean	13,2±1.1	12,1±2.2	10,8±2.4	13,1±2.5	14,6±2.1	13,7±1.9	13,1±1.2	11,7±1.7	12,5±1.4
		supine				Trendelenburg			supine	
					Pneumoperitoneum					
		beforeind	post-ind	mechvent	incision	5	10	30	aftersurgery	afterextub
laparotomy	mean	13,3±1.4	12,4±2.0	10,9±1.7	10,8±1.8	10,9±1.9	10,6±1.7	10,7±1.8	10,8±1.9	11,8±1.4
		supine								
t-test		*0,924*	*0,500*	*0,926*	*≤0,01*	*≤0,001*	*≤0,001*	*≤0,001*	*0,123*	*0,120*

Table 2 - IOP value in the various time of the anesthesia in the two, data are presented as mean (± SD). P<0.05 was considered as statistically significant.

4. Discussion

In this prospective study we compared the changes of IOP during laparoscopic and laparotomic abdominal surgery in pediatric patients. We found in laparoscopic group a significant IOP increase in the Trendelenburg position after pneumoperitoneum introduction, which returned to baseline values in the supine position after pneumoperitoneum evacuation; in fact no changes were seeninto the LT group.

In children from 0 to 12 years, the mean (± standard deviation) IOP is 12.02 (± 3.74) mmHg.IOP showed an increasing trend with age (correlation coefficient [r] = 0.49) and tended to approach adult levels by 12 years of age [5].

Previous studies in adult subjects found an IOP increase during laparoscopic surgery; in particular, one out of 20 women receiving laparoscopic cholecystectomy, a slight but significant increase was found when the abdominal CO_2 insufflation was startedin the Trendelenburg position, and the IOP returned to the preoperative level after the postural change to the head-up position [2].

Several factors can affect IOP during laparoscopic surgery.

The effect of anesthetic procedures on IOP has been well documented during non-ophthalmic surgery, and it is unrelated to changes in BP or HR [3, 5, 6]. As regards to children, it is known that mechanical and pharmacological stress contribute to increase IOP [7-9]. An experimental rabbit model suggested that adequate anesthesia could prevent IOP increase [10].

Many studies have shown that, in children, intravenous hypnotic agents such as propofol, etomidate and thiopental, the non-depolarizing muscle relaxants, and the inhalation anesthetics halothane, isoflurane, sevoflurane, and desflurane, have shown to decrease IOP.

Midazolam and dexmetedomidinedo not seem to influence IOP. In the pediatric population, the role of opioids as decreasing factors of IOP is unclear because used in combination with propofol, even if in adult patients, fentanyl, alfentanil, and remifentanil all decrease IOP[11, 12]. Halstead and al. demonstrated that ketamine also doesn't increase IOP in procedural sedation in children [13]. Depolarizing agents as succinylcholine instead may raise IOP and the administration should be avoided in patients of all ages with injured eyes [14]. Endotracheal intubation is associated with an elevation in IOP [15-17], in part because of the catecholamine response to laryngoscopy [18, 19].

In our study, all patients had endotracheal intubation, and in both groups, we carried out the same induction with sevoflurane and the same kind of ventilation; the IOP increase in LS group should then be ascribed to other factors, mainly the body position and the increased central venous pressure.

IOP is higher in supine than in standing position, and increases at different inclinations in the Trendelenburg position with maximal values in body inversion. In posture changes, the IOP increase is caused by the increase of pressure in the ophthalmic artery and in the orbital and episcleral veins, leading to an engorgement of the choroidal vasculature [20, 21].These changes in IOP corresponded to variations in CVP [22].

The increase in CVP was caused also by pneumoperitoneum introduction, that contributed to IOP increase. Indeed, in hepatic or bladder laparoscopic surgery, that is performed in anti-Trendelenburg position, only mild IOP changes were found.

Lastly, the increase of end-tidal CO_2 found the LS group could also have affected the IOP. A linear relationship was found between IOP and increasing partial CO_2 pressures, with hypocarbia decreasing IOP, and hypercarbia and hypoventilation increasing IOP by a choroidal vasodilatation and CVP increase.

This study has several limitations, mainly the lack of randomization, since this type of surgery was decided by the surgical team. Also patients have different ages.

However our study demonstratesa mild increase in IOP in children, free from previous eye disorders, when placed in the Trendelenburg position after carbon dioxide insufflation during laparoscopic abdominal surgery. Considering that increased IOP, especially for a long period of time, may cause several visual impairments until definitive visual loss, caution is required when children with known or suspected increased IOP undergo these procedures, so both surgical and anesthesiologist teams have to work together optimizing surgical time in laparocopic procedures reducing at the minimum Trendelenburg position and detecting prevently children with previous eye disorders in order to evaluate eventual different surgical strategies. Moreover, from anesthesiologist point of view, the use of anesthetic drugs which don't determine any increase of IOP should be preferred in children undergoing laparoscopic procedures. The maintenance of IOP in the normal range during elective laparoscopic surgery may be beneficial in pediatric patients at risk, but we recommend a future study on the outcome of patients with glaucoma undergoing laparoscopic surgery.

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