

Intermittent pneumatic compression in laparoscopic surgery for prevention of deep vein thrombosis and cellular damage from iatrogenic compartment syndrome



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AIM: This study is aimed to evaluate the incidence of the postoperative deep vein thrombosis (DVT) and the cell damage from compartment iatrogenic syndrome, analyzing two groups of patients operated laparoscopically, one of which assisted with a Sequential Compression Device (SCD).

MATERIAL OF STUDY: A patients' series submitted to laparoscopic surgery over a period at least 90 minutes. The venous flow in the lower limbs was detected with the Echo Colour Doppler method, and only one of the two groups was assisted with the SCD.

RESULTS: Between November 2006 and October 2007, 35 patients were evaluated, 21 of them were assisted with SCD and the remaining 14 patients were the control group. All patients had a follow-up was extended for 5 years at the interval of 7 days, 14 days, 30 days, 3 and 5 years.

DISCUSSION: The results were confirmed that the application of SCD is able to neutralize the negative effect of the PNP reducing the possible risk of thromboembolic venous stasis and the improvement of lactic acid and of myoglobinemia are attributable to a reduction of preload. With the use of IPC, it decreases venous stasis, improves venous return and cardiac output increases, preventing cell damage by hypoperfusion.

CONCLUSIONS: The use of a SCD applied to the lower limbs allows an increase in venous return from the lower limbs so reducing the risk of DVT.

KEY WORDS: Cellular damage, DVT, Pneumoperitoneum

Introduction

Thromboembolic diseases, including deep vein thrombosis (DVT) and pulmonary embolism are major com-

plications of surgical procedures¹. Antithrombotic prophylaxis should be performed by multiple physical or pharmacological methods, including low molecular weight heparin, pneumatic compression and should be based on the stratification of individual and surgical risk factors². In the absence of prophylaxis, the incidence of DVT objectively documented ranges from 10-40%³. Evaluating the surgical risk, it needs to be considered that technically laparoscopic procedures contemplate the establishment of pneumoperitoneum (PNP). With the induction of PNP iatrogenic abdominal compartment syndrome is obtained, characterized by intra-abdominal

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hypertension (IAH) with alteration of the physiology of respiratory, cardiovascular, renal, splanchnic, cerebral systems and teguments^{4,5}.

These alterations may be possible risk factors for surgical DVT so it's necessary to use prophylactic measures pre-, intra- and post-operative. The use of intermittent pneumatic compression (IPC) reduces venous stasis in lower limbs with reduced risk of TVP⁶. IAH can be detected with direct method, as in the course of laparoscopic surgery, or indirect method. The indirect methods are the pressure of the inferior vena cava via femoral vein, trans rectal pressure, gastric tonometry through nasogastric tube, but the gold standard remains measuring bladder pressure⁷⁻⁹.

IPC normally decreases venous stasis, improves venous return and cardiac output and prevents cell damage by hypoperfusion^{10,11}.

To evaluate the possible occurrence of secondary tissue sufferance because of prolonged PNP and whether it can somehow be prevented by the use of IPC, it is useful to evaluate enzyme assays expressing cell lysis (LDH, MG, CK, CKMB) and tissue sufferance on the basis of hypoperfusion (lactic acid) and generally the secondary systemic engagement caused by surgical trauma (AT III, DD).

Materials and Methods

PATIENTS

In our study we enrolled 35 patients undergoing laparoscopic surgery, 19 men and 16 women, older than 18 years old, affected by malignant and benign diseases, with an expected duration of pneumoperitoneum lasting at least 90 minutes.

Inclusion criteria:

- Patients who were affected by benign and malignant disease were applicants for elective surgery laparoscopically;
- Life expectancy of pneumoperitoneum lasting a minimum of 90 minutes;
- ASA classification I-II-III;
- Gave consent to participate to the study.

Exclusion criteria:

- Interventions in Emergency;
- Previous symptomatic deep vein thrombosis;
- Previous symptomatic pulmonary embolism;
- Taking oral contraceptives;
- Duration of pneumoperitoneum less than 90 minutes;
- Patients with conversion of the intervention in laparotomy surgery;
- Hemodynamic instability secondary to hypovolemia.

The majority of patients admitted had at least one risk factor for DVT and about 40% had three or more risk factors.

METHODS

All patients underwent combined general anesthesia.

The induction of PNP took place at speeds of insufflation at 1.5 l/m prior to the attainment of a hold pressure of 14 mmHg.

Intermittent pneumatic compression occurred through a SCD response, with an intermittent cycle divided into 11 seconds of compression step followed by a cycle of individual decompression obtained through automatic analysis performed with a similar technique to plethysmography by the unit.

The evaluation of lower extremity deep venous flow for patient was assessed methodically by the Echo-Colour Doppler (ultrasound Toshiba linear probe of 10 MHz), the systolic velocity peak of the femoral vein and the section of the same, at the confluence of the femoral and saphenous vein. The measurements were taken at four moments, before starting any surgical procedure in order to eliminate possible variations induced by any blood loss.

The measurements were carried out with the following modalities:

- First detection (T0) after induction of anesthesia prior to the application of the pneumoperitoneum supine without IPC;
- Second survey (T1) with pneumatic compression;
- Third detection (T2) after induction of pneumoperitoneum supine without intermittent compression;
- Fourth detection (T3): as T2 with IPC.

Each measurement was repeated three times at intervals of 5 minutes, in the results it shows the average value of three measurements.

We measured a number of variables enzyme assays expressing cell lysis (LDH, MG, CK, CKMB) and tissue sufferance on the basis of hypoperfusion (lactic acid) and generally the secondary systemic engagement caused by surgical trauma (AT III, DD). In fact, for the evaluation of the pathophysiological effects of cell damage from compartment syndrome, following parameters were taken into account: LDH, CK, CK MB, MG ATIII DD and assay of lactate were detected by sampling blood chemistry in the pre operative at 60 minutes, 120 minutes, 6 hours, 12 hours, 24 hours and 48 hours after surgery.

A follow-up was performed at 30 days after surgery and also at 3 and 5 years with clinical-instrumental evaluation using Doppler ultrasound and laboratory investigations.

Results

Between November 2006 and October 2007, 35 patients undergoing laparoscopic surgery were enrolled, 19 men and 16 women, who started a post operative follow-up at

TABLE I

Surgical Intervention Type with SCD	Number
Empathic cyst excision	1
Diagnostic Laparotomy	3
Sigmoid Resection	1
Miles intervention	2
Total gastectomy	1
Right Colectomy	3
Total Colectomy	1
Video Laparoscopic Surgery	6
Left Colectomy	1
Total	21

TABLE II

Surgical Intervention Type with SCD	Number
Catheter positioning	1
Surrenalectomy	1
Video Laparoscopic Surgery	4
Intestinal Recanalisation	3
Left Colectomy	1
Abdominal laparocoele	1
Right Colectomy	1
Miles Intervention	1
Diagnostic Laparotomy	1
Total	14

3 and 5 years. The results are listed in Tables I and II. The average duration of the PNP was 151 minutes (ranging from 90 minutes to 400 minutes). There were 21 patients which were assisted with the SCD, while the control group was made up of 14 patients; demographic characteristics of these two groups are listed in Table II. The follow-up carried out after 7 days, 14 days and 30 days post surgery did not reveal any clinical signs of DVT. At 60 days two of the 14 patients undergoing laparoscopy no SCD assisted presented DVT treated with sodic Enoxaparina and controls with Doppler ultrasound. Control group also showed early signs of cellular suffering.

Discussion and Comments

According to the hemodynamic consequences of PNP we wanted to verify if the application of an intermittent pneumatic compression device (SCD) could contribute to increase the flow rate at the level of the deep veins of the lower limbs resulting in increased preload, therefore eliminating a key component in the pathogenesis of DVT.

The insufflation of gas inside the abdominal cavity determines alterations of homeostasis reflected mostly in car-

TABLE III - Evaluation of the deep venous flow of the lower limbs

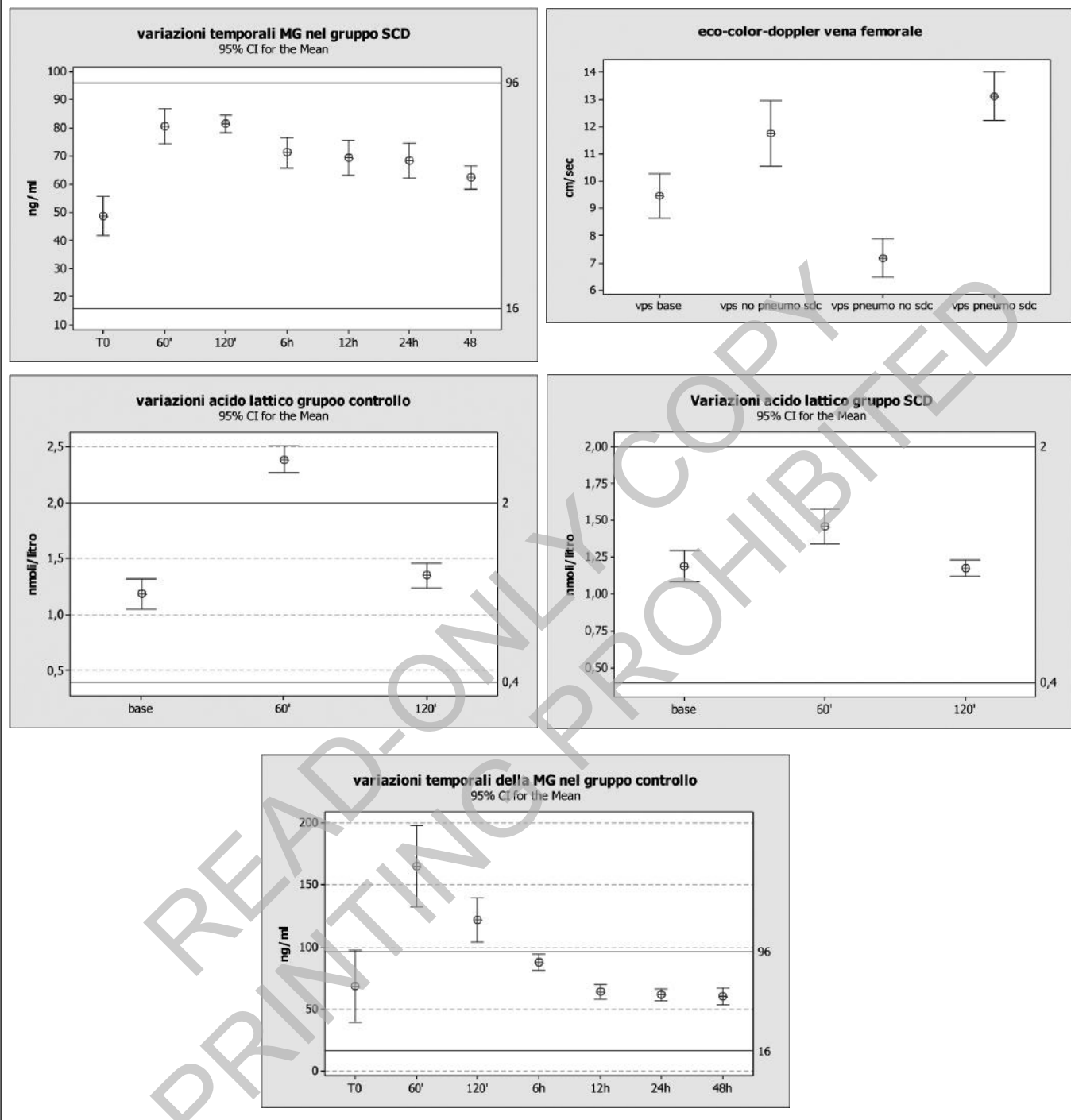
Pz	T0		T1		T2		T3	
	VPS	A	VPS	A	VPS	A	VPS	A
1	7,7	81	9,2	87	6,5	101	8,8	183
2	11,1	113	19,3	201	7,9	120	15,8	185
3	7,9	70	6,1	96	6,7	156	14,3	143
4	9,1	100	12,9	117	7,5	102	15,6	158
5	8,1	80	11,2	100	6,5	95	13,4	130
6	6,9	95	10,1	100	7,1	170	11,1	180
7	8,0	90	11,4	110	6,8	145	10,5	174
8	12,8	100	14,8	130	7,5	156	13,5	189
9	7,5	120	9,0	149	8,2	168	14,7	168
10	9,5	96	11,8	116	7,3	146	13,6	178
11	9,4	110	12,5	143	8,0	167	14,3	185
12	10,1	84	13,0	98	6,4	135	13,8	167
13	12,0	101	14,1	124	9,0	157	14,3	184
14	8,5	110	10,9	129	6,4	149	11,4	191
15	12,3	98	14,1	112	9,8	124	15,8	179
16	10,1	120	13,2	146	8,5	178	14,6	169
17	8,3	96	9,8	113	7,8	149	10,6	175
18	9,3	112	10,7	135	6,7	158	13,7	185
19	8,9	113	10,5	142	6,3	172	11,9	189
20	12,7	98	10,9	121	8,4	148	14,5	172
21	9,8	95	11,1	134	7,4	173	11,0	166

VPS: speed of the systolic pic; A: area of femoral vein

diovascular and respiratory systems^{12,13}. The insufflation of gas increases intra-abdominal pressure which can decrease venous return (by compression of the peripheral and splanchnic venous circles) and a compensatory tachycardia can result because of sympathetic reflex¹⁴. In fact PNP causes a compensatory vasoconstriction with a consequent increase in peripheral resistance and decrease venous return to the heart. The effects of PNP on respiratory system are mainly related to lung volume reduction caused by the dislocation of the diaphragm upward, by the retention of CO₂ and the resulting hypercapnia; other effects are represented by increasing resistances on the airways and reduction of vital pulmonary capacity¹⁵. Our results therefore confirmed that the PNP induces a statistically significant reduction of the speed of Peak Systolic (VPS) (P 0.03) and thus constitutes a real risk factor for venous stasis DVT especially if this is prolonged as it happens habitually for cancer surgery which are increasingly performed by video-assisted technique and it can expose the patient to an increased risk of thromboembolic events.

On the other hand the device for intermittent pneumatic compression SCD increases the venous return in basal conditions (P 0.01). In the course of PNP the use of intermittent pneumatic compression compensates the effects of PNP in terms of venous return (if T3 vs T2 = p <0.01) and in any case is able to increase the venous return from the lower limbs with respect to the conditions basal (P 0.03).

PAIRED T-TEST



Our results confirmed that the application of the device in the course of laparoscopic surgery is able to neutralize the negative effect of the PNP and this reduces the possible risk of thromboembolic venous stasis. It is important, however, that this effect is manifested by pressures of PNP to values no higher than 15-16 mmHg, which are commonly used in laparoscopic practice.

Our statistical analysis shows that in the first group the trend of the systolic peak velocity (VPS) has a sinusoidal pattern (diagram A) and the VPS decreases with the induction of PNP, without using IPC and this pattern turns to its baseline value when the compression is applied. The increase of VPS is reflected at the preload, and consequently, it increases cardiac output. Also VPS'

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growth reduces blood stasis at the level of large veins of lower limbs. The evaluation with ECO-Doppler of the saphenous vein showed a progressive increase after application of the device SCD (p 0.01), after PNP (p 0.03) and finally after SCD with PNP (p 0.02).

However, the data appears not easy to interpret, because an increase in vascular sections within the veins is usually an expression of venous stasis, so if the increase in the area of the femoral vein was an expected outcome after induction of pneumoperitoneum, we would have expected a reduction with SCD without PNP and possibly a moderate increase when the PNP was created. It must be stressed, moreover, that the measurement of the systolic peak rate with ECO-Doppler (method widely validated in the literature and in clinical practice) showed a clear increase.

In the group of patients assisted with the device, both indices of cytotoxicity and tissue suffering started at the baseline and those increases are maintained in normal range. Only LDH started and increase at the beginning of 60 and 120 minutes and at 6 hours and 12 hours had the levels returned normal.

In control group a significant change was observed in the immediate postoperative time, especially myoglobinemia (p <0.02) and lactic acid (p <0.01). They returned to normal range at 12 hours after surgery. Also for the LDH we observed the same previous pattern.

The variation of lactic acid and of myoglobinemia in control group can be attributed to the reduction of preload that can be normal in patients undergoing laparoscopy without using IPC. Indeed the decrease of the preload, of cardiac output and consequently tissue perfusion alteration can be a cause of suffering of smooth and striated muscles. This is confirmed by the increase in lactic acid production by the tissues highlighted in our results.

CONCLUSIONS

The present study confirms that major surgical procedures can also be conducted with video-assisted technique and the PNP use for a long operative time.

One of the main safety factors is represented by pressure that is applied during induction and maintenance of the PNP and should not exceed 14-15 mmHg. In these conditions, significant hemodynamic alterations do not occur, especially in terms of adequate venous return. Prolonged PNP supports temporary and low biochemical alterations, which are expression of suffering tissue and cell damage, even with relatively low intra-abdominal pressure.

Patient that need a long laparoscopic procedure have to be assisted with a device for intermittent pneumatic compression applied to lower limbs. It allows to increase the speed of venous flow to the district inferior vena cava, decreases the risk of post-operative DVT, improves tissues perfusion and avoids ischemic damage.

In chirurgia laparoscopica l'induzione del pneumoperitoneo (PNP) realizza una sindrome compartimentale iatrogena con ripercussioni sul circolo venoso profondo degli arti inferiori. In questo studio abbiamo voluto valutare l'incidenza di Trombosi Venosa Profonda (TVP) postoperatoria e del danno cellulare da sindrome compartimentale iatrogena analizzando due gruppi di pazienti, ad uno dei quali è stato applicato un dispositivo Sequential Compression Device (SCD). I pazienti selezionati sono stati suddivisi in due gruppi e sono stati sottoposti a chirurgia laparoscopica con durata non inferiore a 90'. È stato rilevato con metodo ECOCOLOR-DOPPLER il flusso venoso degli arti inferiori e soltanto ad uno dei due gruppi è stato applicato un dispositivo SCD. Da novembre 2006 a ottobre 2007 sono stati valutati 35 pz, 21 pz con dispositivo SCD e 14 pz utilizzati come gruppo controllo, con follow-up a 7 gg, 14 gg, 30 gg, a 3 e 5 anni. L'utilizzo di un dispositivo SCD applicato agli arti inferiori consente un aumento del ritorno venoso dagli arti inferiori diminuendone il rischio di TVP.

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