EVOLUTION OF PULMONARY PRESSURE AND VOLUME IN HEART SURGERY

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ABSTRACT

Heart surgery causes physiopathologic changes to happen that contribute to the development of pulmonary complication in post-surgery. Generally there occurs abnormalities in respiratory muscular related mainly to the loss of capacity to generate force. Due to the knowledge of the deleterious effects of surgery on respiratory muscular and its repercussion in the pulmonary function, the objective of this study was to analyse the evolution of pulmonary pressure and volume, from pre-surgery to discharge from hospital. A study was carried out with ten patients having heart disease selected and submitted to heart surgery, average age 55 ±12.2 years old. The patients were evaluated according to the measurement of maximum respiratory pressure, pulmonary volume and respiratory frequency, besides the data collected in the patient's records. In a statistical analysis, it was observed a significant decrease in the respiratory pressure variable, between the pre-surgery and the discharge from hospital as well as in the comparison of the post-surgery itself. The pulmonary volume was significantly smaller between the pre-surgery and the second day post-surgery. These results suggested that the patients presented weakness of respiratory muscular from pre-surgery, which was deepened, after the surgical procedure provi-

ding a superficial respiratory standard. As a conclusion, the respiratory physiotherapeutic evaluation is fundamental from the pre-surgery, to prevent the changes related to the pulmonary function.

KEY WORDS: pulmonary volume; maximum respiratory pressure; heart surgery; respiratory physiotherapeutic evaluation

INTRODUCTION

Heart surgery has improved in recent decades becoming a routine intervention in great and middle sized hospitals that treat cases for surgery of coronary artery revascularization, congentinal or valvar problems (ELIAS et al., 2000).

Generally speaking, cardiac surgery has close relation to factors such as the effect of anesthesia, type of surgery, cardiac pathology, surgical incision, use of extracorporeal circulation (ECC) and the hemodinamic status in relation to the pulmonar function of the patient (AZEREDO, 2000).

Regarding many studies on the work of respiratory muscles it was possible to verify that most patients show respiratory complications after surgery, most of the time due to reduced respiratory muscle strength or muscular fatigue (ELLIAS et al., 2000).

The most common procedure for respiratory muscle evaluation is the measurement of the maximum inspiratory pressure (MIP) and of the maximum expiratory pressure (MEP), which are measured by an manovacuometer (RONCATI et al., 1998).

Normal values for maximum respiratory preassures depend on age and sex, decreasing with age (LEHNKUHL. SMITH, 1989; MCELVANEY et al., 1989; ENRIGHT et al., 1994). Elder and diseased people can show reduction of up to 25% of MIP and MEP (ENRIGHT et al., 1994). According to Balck and Hyatt (1969) there is no significant regression for MIP and MEP values in individuals below 55 years. Only in individuals beyond this age value for MEP in males and females and values for MIP for females decrease with age.

In cardiopats the cardio-respiratory compromise is restricted to physical activity, mainly in stages showing intense dyspnea leading to decrease in the lung volumes and capacity. When submitted to surgery these deficits are heightened (ELIAS et al., 2000). According to Weiner et al. (1998) weakness of respiratory muscles is associated, directely or indirectely, to damage to this musculature during surgery leading to situations ranging from dysfunction to total

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failure of respiratory muscles (GASS; OLSEN, 1986; BERRIZBEITIA et al., 1989; LOCKE et al., 1999).

In the postoperative period there is a reduction in all lung volumes caused by: diafragmatic dysfunction, pain, absence of deep respirations, lung and toraxic alterations. The functional residual capacity (FRC) is reduced due to reduction of the residual volume (RV) and of the volume of expiratory reserve (VER). Ventilation is also compromissed due to the reduction of the current volume (VC) and by the increase in the respiratory frequence (RF) (SHELDON et al., 1978; HEDERSTIERNA et al., 1985; OLSEN, 1992; LINDBERG et al., 1994; CAVALCANTI; RODRIGUES, 1995; BARISIONE et al., 1997; OLSEN et al., 1997; SIAFAKAS et al., 1999). The sum of these factors causes alterations in the respiratory mechanics leading to a superficial respiratoy pattern due to reduced lung volumes (FARGS, 1985; FORD et al., 1993).

In the postoperative period there is also reduction of the maximum inspiratory preassures, transdiafragmatioc preassure and diafragmatic preassure indicating a reduction of the respiratory muscular force (LOCKE et al., 1990; FORD et al., 1993). The function of the respiratory muscles in the postoperative period may be affected by lesion in the muscle or its nerves as a consequence of the incision or alteration in the mechanics of the respiratory systmem. Distortion of the toraxic wall may reduce the toraxic complacence increasing the respiratory work (SIAFAKAS et al., 1999).

According to Hsia et al. (1993) those patients presenting weak respiratory muscles in the preoperative period have a greater risk to develop lung complication in the postoperatory. Awareness on the deleterious effecs of surgical procedures on the respiratory muscles and its reperctution in the lung function and in the incidence of respiratory complication in the postoperatory have estimulated sutudies on the evaluation and prevention of harm to the function of respiratory muscles in the pre and postoperatory periods (MAEDA et al., 1988; CELLI, 1993; FORD et al., 1993; HSIA et al., 1993; NOMORI et al., 1996; SIAFAKAS et al., 1999).

Taking this into consideration the analysis of cardiac intervention can point and direct studies related to the evaluation of the respiratory muscular force and lung volumes in cases submitted to these operations. Thus, the objective of the present study is to investigate the evolution of the maximum respiratory pressure, lung volumes and respiratory frequency in patients submitted to cardiac surgery from the preoperatory to the discharge.

PATIENTS AND METHODS

Thirteen cases were initialy evaluated and three were excluded due to impossibility to performe test and two cases of death. The final sample consisted of 10 cases (6 females and 4 males) with average age of 55.0 ± 11.2 years. The study was conducted from november 2000 to January 2001. The committee on Ethics aproved this study and the patients gave their free consent.

Criteria for intake of cases included valvulopaties and coronary artery disease; age 30-70 years; elective cardiac surgery. Cases were excluded in case of intra-aortic ballon; pregnancy; associated severe muscular and skeletic pathologies, neurologic involvement, re-operations, hemodinamic instability, impossibility to proceed with measurements and death.

Patients were submitted to physical therapy evaluation in the preoperatory (PRE), at the second day of postoperatory (2nd PO), third day (3rd PO), fourth day (4th PO), fifth day (5th PO) and discharge from hospital (DIS). Data colletion was made in a previously prepared protocol.

Evaluated variables were maximum respiratory preassures MIP CRF, MIP VR and MEP), RF and CV and minute volume (MV).

The maximum respiratory preassures were measured according to the method proposed by Black and Hyatt (1969) using a manovacuometer RECORD – GER-AR previously calibrated. This equipment has the objective to measure the positive preassures (MEP) and negative presures (MIP) with an operational interval ranging from –150 to +150 cm H_2O. Pressures were verified using an mouth adaptator connected to the intermediate piece of the manovacuometer. To the evaluation of the MIP there was a hole of 1 to 2 mm in the mouth piece to prevent interference of the oral cavity muscles. The opening in the intermediary was closed during the measurement while the patient put presure on the mouth piece with his/her lips.

These procedures were repeated three times and the maximum value was recorded provided it was not the last one and that the preasures maintained for at least one second allowing one minute of rest between each effort. The last value was greater than 20%, a fourth measurement would be made.

The RF was measured in cyles per minute (cpm) observing the movement of the chest wall during the evaluation of MV. The minute volume was measured by ventilometry using a mechanic ventilometer (OHMEDA). The current volume (CV) was obtained by the proportion MV/RF.

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During the measurements patientes were seated and resting with nostril closed by a nasal clamp.

For the physical therapy evaluation some data were collected from the patients' files such as diagnosis, personal data, weight, heigt, personal antecedents, type of surgery, surgical incision, period of extracorporeal circulation, period of orotracheal intubation (OTI) and physical therapy follow-up.

Friedman test was used to compare the pulmonar evolution between the PRE, POST and DIS moments. The relation of PRE and DIS was made by the Wilcoxon test. When the result was significant it was used the Dunn multiple comparison method. For all tests the level of significance was 5% (ARMITAGE; BERRY, 1997).

RESULTS

In TABLE 1 it can be seen the characteristics of patients.

TABLE 1 – Characteristics of patient.

Patient	Diagnosis*	Sex	Age	Type of ** surgery	Surgical *** incision	ECC
1	V	female	51	VI	ALT	yes
2	V	male	35	VI	MST	yes
3	C	male	64	MR	MST	yes
4	C	female	67	MR	MST	yes
5	C	male	35	MR	MST	yes
6	C	female	55	MR	MST	no
7	C	male	68	MR	MST	yes
8	V	female	63	VI	MST	yes
9	V	female	56	VI	ALT	yes
10	V	female	39	VI	MST	yes

*Diagnosis: C = coronary disease, V = volve disease
** Type of surgery: VI = valvle implant, MR = miocardic revascularization
*** Surgical incision: ALT = anterolateral toracotomy, MST= medium sternal toracotomyl

Values according to the periods of ECC, surgery, anesthesia and OTI can be seen in TABLE 2.

TABLE 2 – Distribution of period of ECC, surgery, anesthesia and OTI among individuals

Period	Mean	SD	Median	Minimum	Maximum
ECC (min)	94.9	55.4	105	84	159
OTI (h,min)	14h48min	4h6min	13h48min	11h	14h48min
Surgery (h,min)	5h	0.6h	5h8min	3h35min	5h40min
Anesthesia (h,min)	5h57min	0.4h	6h	5h	6h35min

The evolution of the lung function from the peroperatory until discharge can be seen in TABLE 3. There was a significant difference between maximum respiratory preassures and respiratory frequency (FR). In TABLE 4 and FIGURE 1 to 5 it can be seen mean values and the significance of each studied variable when compared at moments PRE, PO and DIS.

TABLE 3 – Results for Wilcoxon test for paired data coparing the evolution of the lung function at the preoperatory and at the discharge.

Parameter	Wilcox(Z)	P	Result	Comment
MIP CRF	2.8	0.005	Signif.	MIP PRE>MIP DIS(CRF)
MIP VR	2.5	0.012	Signif.	MIP PRE>MIP DIS(VR)
MEP	2.7	0.008	Signif.	MEP PRE > MEP DIS
RF	-2.4	0.017	Signif.	RF PRE < RF DIS
CV		(0.432)	No signif.	CV PRE=CV DIS
MV		(0.322)	No signif.	MV PRE=MV DIS

TABLE 4 - Friedman's variance analysis and multiple comparison by Dumn's test between the PRE, 2nd PO, 3rd PO, 4th PO, 5th PO and DIS in elective cardiac surgeries for the following variables: MIP CRF, MIP RV, MEP, RF, CV and MV.

Variable	Fried.(T)	P	Result	Coment
MIP CRF	24.4	<0.0001	Signif.	2ndPO=3rdPO<4thPO=5thPO=DIS<PRE4thPO<DIS
MIP RV	24.2	<0.0001	Signif.	2ndPO=3rdPO<4thPO=5thPO=DIS<PRE
MEP	16.8	<0.0001	Signif.	2ndPO=3rdPO=5thPO=4thPO<DIS<PRE2ndPO<4thPO
RF	8.6	<0.0001	Signif.	2ndPO=3rdPO=4thPO=5thPO=DIS2ndPO =3rdPO=5thPO<PRE4thPO=DIS=PRE
CV	3.4	0.0115	Signif.	2ndPO=3rdPO=4thPO=5thPO=DIS=PRE2ndPO<PRE
MV	3.2	0.0144	Signif.	2ndPO=3rdPO=4thPO=5thPO=DIS=PRE2ndPO<PRE

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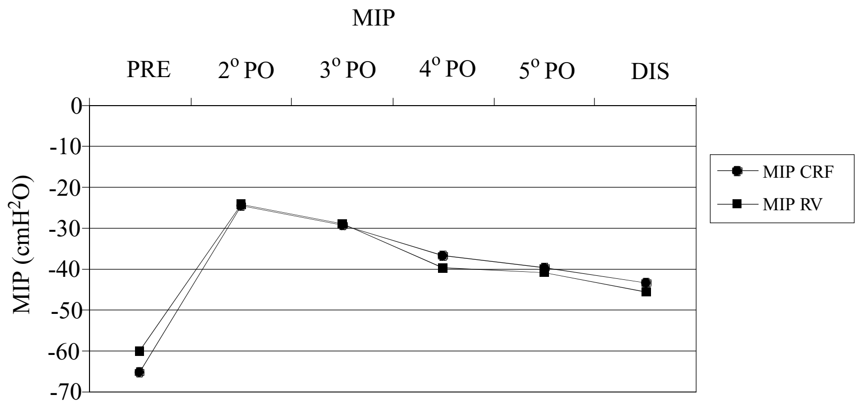

FIGURE 1 – Mean MIP CRF and RV in the preoperatory, postoperatory and discharge moments.

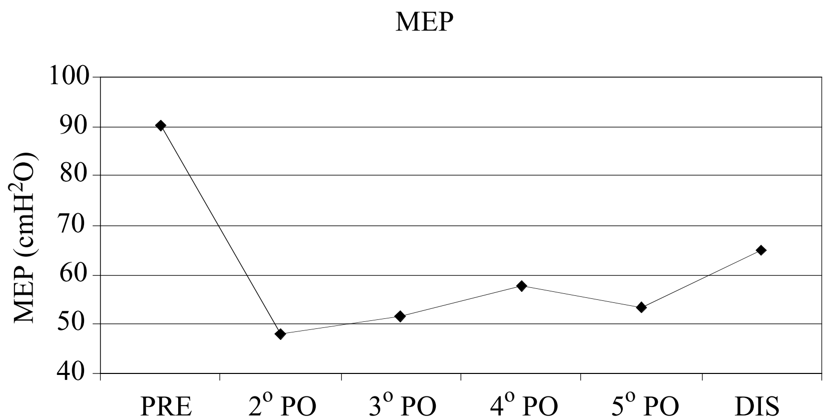

FIGURE 2 - Mean MEP in the preoperatory, postoperatory and discharge moments.

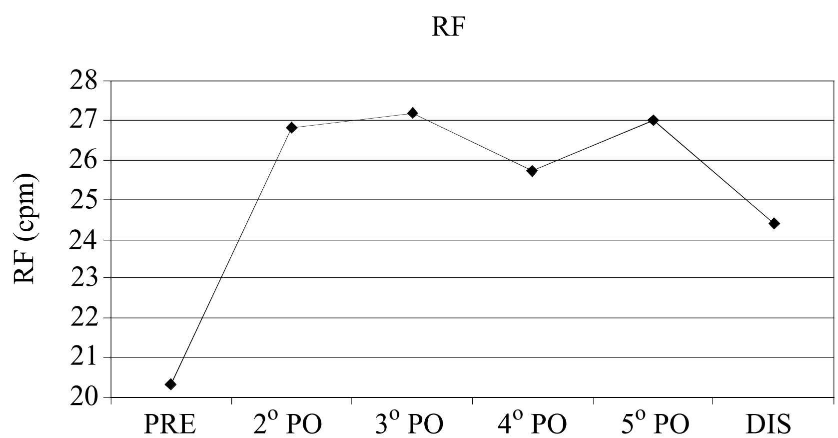

FIGURE 3 – Mean RF in the preoperatory, postoperatory and discharge moments.

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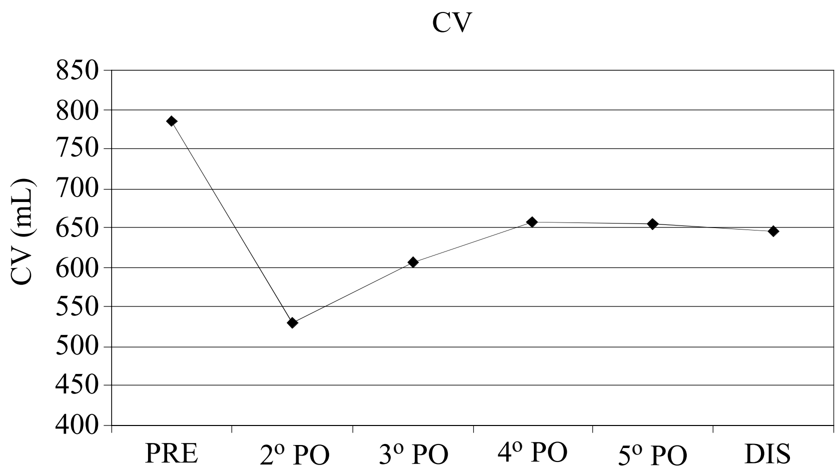

FIGURE 4 – Mean CV in the preoperatory, postoperatory and discharge moments.

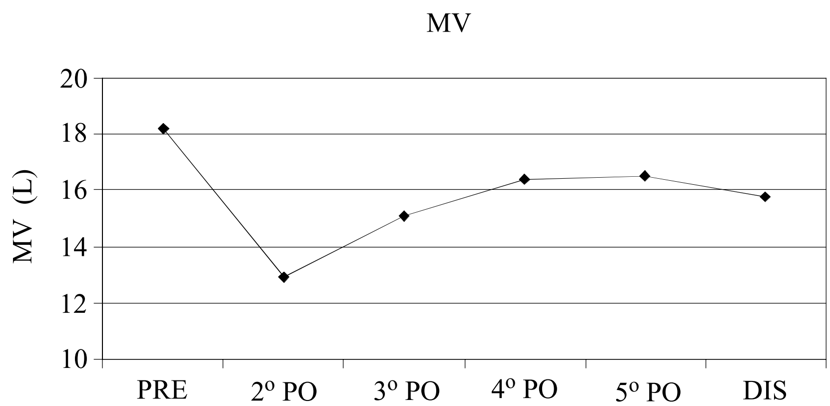

FIGURE 5 – Mean MV in the preoperatory, postoperatory and discharge moments.

DISCUSSION

In cardiopaths the respiratory involvement is secondary to the low cardiac debit. The decrease in the left ventricular function leads to a decrease in the blood flow to the respiratory muscles that can cause dispnea and disturbances to the activities of the patient. Due to this it is observed some decrease in the lung capcity and volumes that are exacerbated when such patients undergo cardiac surgery (PONTE, 1991; KISNER,1998; WEINER et al., 1998; AZEREDO, 2000; ELIAS et al., 2000). Such facts were observed in the present

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study. Indeed, patients after surgical procedrue presented a restrictive pulmonar pattern. It was observed alterations in the CV and MV, which were significant a the 2nd PO and gradually returned to normality at the 5th PO, a fact that was observed also by Cavalcanti and Rodrigues (1995).

Many studies have reported that the alterations in the pulmonar volumes in the preoperatory are due to factor such as diafragmathic dysfunction, pain, absece of deep inspiration, lung and toraxic cage alterations. These findings returns to normality only at the 3rd month after operation (GASS; OLSEN, 1986; BERRIZBEITIA et al.,1989; LOCKE et al.,1990; e WEINER et al.,1998). Locke et al. (1990) have also suggested that the reduction and discoordination of the toraxic expansibility contribute to the restrictive ventilatory pattern that follows a median esternotomy; it is believed that this same fact occurred with the patients in the present study since 80% of the cases have undergone a medio-esternal toracotomy. All these factors may cause dysfunction in the respiratory mechanics leading to reduced pulmonary volumes that results in a superficial respiratory pattern and increase in the RF (FARGA, 1985; FORD et al. 1993).

In what regards the respiratory frequency (RF), results in the postoperative moment suggest a significant increase of this parameter in all moments without returning to normality at discharge, which is also reported by Locke et al. (1990)

It is believed that this increase in the RF may be related to the increase in the CV and MV from the 2nd PO until discharge since low pulmonary volumens generates a superficial respiratory pattern that contribute to an increase in the RF in the attempt to assure pulmonary volumes. Similar data was reported by Locke et al. (1990).

Maximum respiratory pressures (MIP and MEP) depend on the pulmonar volume. Azeredo (2000) has demonstrated that MEP may be measured from the total pulmonar capacity (TPC) and the MIP from, RV and CRF. Camelo et al. (1985) analyzed the curves that correlated pulmonar volume and alveolar pressure during maximum efforts in static conditions and observed that MIP are greater in volumes near the RV and MEP are greater in volumes near the TPC. However, Busch et al. (1992) did not find any significant relation in inspiratory pressures in CRF and RV in healthy individuals, which agrees with the present results even though taking into consideration that cases in this study were submitted to surgery.

By analysing the obtained results in relation to the maximum respiratory preassures it can be observed that MIP CRF, MIP VR and MEP showed statistical significance among PRE and DIS as well as in the comparisons of PO among themselfs. The values for PRE were low when compared to values taken as normal as described in the literature (BLACK; HYATT, 1969; WILSON et al., 1984; LOCKE et al.,1990; WEINER et al., 1998). However, taking into consideration the studies of Oliveira et al. (1996) and Elias et al. (2000) conducted in the same institution and with population similar to the one used in the present study, its was observed similarly low values.

These low values may be attributed to the individuals included in the present study. Out of them, 80% of males and 50% of women were above 55 years old and 60% of the whole samples was of females. These findings are in accordance to those of some authors (BLACK; HYATT, 1969; MCELVANEY et al.,1988; LEHNKHL; SMITH, 1989; BRUSCHI et al.,1992) that suggested the existence of some influence of the age in the maximum respiratory pressures in individuals above 55 years and mainly in females. On the other hand, Wilson et al. (1984) reported that the respiratory pressures are age related only to males. Besides, it was noted that the capacity and the degree of coordination to perform maneuvres are also important reasons for interindividual variations, which was also observed by Bruschi et al. (1992).

Taking into consideration that the studied individuals were cardiopaths and present reduced blood flow, it should be stressed the reduced offer of oxigen to tissues, which can result in important hazard to the pulmonary function. These conditions of muscular respiratory hazard are found in the PRE and are intensified after the cardiac surgery.

According to Barbas et al. (2000) the respiratory muscles in normal condition and at rest requires circa 5% of the total body oxygen consumption. Patients in the present study after the cardiac operation were submitted to mechanic ventilation for 14 hours in average; this adverse condition to the respiratory muscles takes 50% of the total body during weaning, requiring more respiratory effort. This fact added to ECC, OTI, type of surgery, period of anesthesia, muscular incision, pain and metabolic alteration may cause an additional overload to a previously weakened musculature. In what regards the period of ECC, OTI, surgery and anesthesia the obtained results in the present study are within the normality and were similar to those reported by Cavalvaty and Rodrigues (1995).

Authors, such as Maeda et al. (1988), Celli (1993), Ford et al. (1993), Hsia et al. (1993), Nomori et al. (1996) and Siafakas et al. (1999), report the importance of studies on the evaluation and treatment of the respiratory muscular function from the preoperatory since it reduces the deleterious effects faced after the operation. This fact was also observed in the present study.

CONCLUSIONS

Results of the present study lead to the following conclusions:

1 – After surgery patients show a restrictive respiratory pattern;

2 – Patients showed respiratory muscular weaknes in the preoperatory that became marked after operation, as shown by the low values for MIP and MEP.

3 – Respiratory physical therapy evaluation in the preoperatory is of utmost importance to detect possible alteration and leading to intervetions when necessary.

4 – In institutions with limited resources the assessment of maximum respiratory pressures with a manovacuometer has shown efficient to the evaluation and design of treament in patient to undergo cardiac surgery.

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