

Effects on respiratory function of the head-down position and the complete covering of the face by drapes during insertion of the monitoring catheters in the cardiosurgical patient

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Background: We evaluated the effect on the respiratory gas exchange of the 30° head-down position and the complete covering of the face by sterile drapes. These are used to cannulate the internal jugular vein and position the pulmonary artery catheter in the cardiosurgical patient. During the two manoeuvres, 20 coronary patients and 10 patients with end-stage heart disease were supplied with oxygen ($F_iO_2=0.4$) by a Venturi mask, while 20 coronary patients breathed room air. The arterial blood samples to measure oxygen (PaO_2) and carbon dioxide ($PaCO_2$) tension and oxygen saturation (SaO_2) were analysed by a blood gas system.

Results: The contemporary application of the head-down position and the drapes over the face significantly increased PaO_2 and SaO_2 in all the patients supplied with oxygen. Without the head-down position, leaving the drapes over the face, did not significantly change the two parameters in the coronary patients supplied with oxygen, but induced a significant increase in PaO_2 and SaO_2 in the patients with end-stage heart disease. In the coronary patients that were breathing room air, PaO_2 and SaO_2 were stable throughout the study.

Conclusions: We conclude that the 30° head-down position and the complete covering of the face by drapes does not interfere with respiratory gas exchange and can be safely performed in coronary patients supplied with oxygen or breathing room air and in patients with end-stage heart disease supplied with oxygen (F_iO_2 of 0.4).

Introduction

The complete covering of the face by sterile drapes is a manoeuvre routinely used to cannulate the internal jugular vein and position the pulmonary artery catheter. The head-down position is a manoeuvre associated with that of sterile drapes when particular conditions (big and short neck, hypovolemia) make the cannulation of the jugular vein difficult [1]. Experimental and clinical studies have shown that the head-down position can interfere with respiratory function by reducing the functional residual capacity (FRC) and increasing the pulmonary blood volume [2–4]. A literature search found no data supporting a negative effect on respiratory function with the drapes covering the face; however, we hypothesized such a negative influence, supposing that the application of the sterile drapes over the face can favour the rebreathing of the expired gases. The aim of this study was to evaluate the effect on respiratory gas exchange of the two combined manoeuvres used during the insertion of monitoring catheters in the cardiosurgical patient before induction of anaesthesia.

Methods

Fifty-four patients scheduled for elective coronary bypass grafting (CABG; 43 coronary patients) and heart trans-

plantation (11 patients with end-stage heart disease) were studied. The study protocol was approved by the local Ethical Committee, and written informed consent was obtained from each patient. Admission criteria for the study were: no history of respiratory disease and no intravenous cardiovascular drugs (for all patients); stable haemodynamic conditions, assessed by clinical examination, and no unstable angina (for patients undergoing CABG); and no rest dyspnoea (for patients undergoing heart transplantation).

Before induction of anaesthesia, all patients were placed in the head-down position (30°) and had their face completely covered by sterile drapes (Foliodrape, Hartmann, Heidenheim, Germany) to position the monitoring catheters. The head-down position was maintained until the internal jugular vein was cannulated, while the sterile drapes were removed after the pulmonary artery catheter was inserted. The coronary patients were randomly divided into four groups:

Group A1 ($n=10$), coronary patients with preoperative left ventricular ejection fraction (LVEF) $>45\%$, supplied during the two manoeuvres with oxygen by a Venturi mask (REF 001240G, Allegiance Healthcare Corp,

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Illinois, USA) suitable to guarantee a concentration of oxygen in the inspired gases of 40% ($F_iO_2=0.4$);

Group A2 ($n=10$), coronary patients with preoperative LVEF >45% breathing room air during the two manoeuvres;

Group B1 ($n=10$), coronary patients with preoperative LVEF <45% supplied with oxygen ($F_iO_2=0.4$);

Group B2 ($n=10$), coronary patients with preoperative LVEF <45% breathing room air;

Group C ($n=10$), patients with end-stage heart disease were admitted consecutively to the study and were supplied with oxygen ($F_iO_2=0.4$).

In all patients, LVEF was assessed by cardiac angiography.

The arterial blood samples to determine oxygen (PaO_2) and carbon dioxide ($PaCO_2$) tension and oxygen saturation (SaO_2) were drawn at the following times:

time 1=in supine position with all patients breathing room air;

time 2=in supine position only in patients supplied with oxygen by the Venturi mask (groups A1, B1 and C);

time 3=just before removing the patient from the 30° head-down position;

time 4=just before removing the drapes covering the face;

time 5=5 min after the drapes have been removed.

The analysis of the blood samples was performed by the same operator, using a blood gas system (model 288, Ciba Corning Medfield, Massachusetts, USA) located just outside the operating room. The coronary patients were premedicated with morphine 0.1 mg/kg and scopolamine 0.3–0.5 mg intramuscularly; the patients with end-stage heart disease were premedicated with diazepam 3–5 mg orally. All of these drugs were administered 60 min before entering the operating room. Monitoring of the patients

during the study included an electrocardiogram (ECG) (DII–V5), and measurements of the invasive arterial pressure, noninvasive oxygen saturation and respiratory rate. We excluded from the study three coronary patients (two for an anginal episode and one for restlessness) and one patient with end-stage heart disease (for restlessness), as the drapes were temporarily removed in these patients, and nitroglycerin or benzodiazepine were administered.

The results are expressed as means ± standard deviation (SD). The data were analysed using the Student's *t* test with Bonferroni correction; *P* values <0.05 were considered statistically significant.

Results

The main data on the general characteristics of the patients (age, weight, preoperative LVEF, preoperative therapy) are reported in Table 1; the times of the head-down position and covering of the face by drapes are reported in Table 2. There were no significant differences among the five groups regarding age, weight and the duration of the two manoeuvres. The results on the behaviour of the arterial respiratory gas tension and the haemoglobin oxygen saturation at the five times are shown in Table 3.

Compared with the basal conditions and time 1 for groups A2 and B2 and time 2 for groups A1, B1, C, PaO_2 and SaO_2 increased significantly ($P<0.05$) in all patients supplied with oxygen (groups A1, B1, and C) at times 3 and 4. A similar comparison between times 3 and 4 showed a small nonsignificant increase in PaO_2 and SaO_2 in groups A1 and B1, and a significant increase ($P<0.05$) in PaO_2 and SaO_2 in group C. After stopping the head-down position and removal of the drapes covering the face (time 5), PaO_2 and SaO_2 returned to the values similar to those recorded at time 2.

Table 1

General characteristics of the patients studied

	Groups				
	A1	A2	B1	B2	C
Weight (kg)	73 ± 10	80 ± 14	76 ± 14	73 ± 10	75 ± 10
Age (years)	60 ± 11	58 ± 8	63 ± 7	61 ± 7	55 ± 6
LVEF (%)	68 ± 5	65 ± 8	33 ± 8	36 ± 5	22 ± 5
Preoperative therapy					
Nitroderivates (<i>n</i>)	8	6	10	8	5
β-Blockers (<i>n</i>)	10	8	6	6	1
Calcium antagonists (<i>n</i>)	3	5	2	4	
Digoxin (<i>n</i>)			1	3	10
Furosemide (<i>n</i>)			2	1	10
ACE inhibitors (<i>n</i>)		2	7	3	7

No significant difference was observed among the five groups for age, weight and left ventricular ejection fraction (LVEF). ACE, angiotensin converting enzyme. For definition of groups, please see text.

Table 2

	Groups				
	A1	A2	B1	B2	C
Head-down time (min)	8.2 ± 3	7.7 ± 2	9.6 ± 7	8.3 ± 3	8.1 ± 2
Drape time (min)	16.1 ± 3	17.3 ± 4	17.1 ± 10	15.8 ± 4	15.5 ± 2

No significant difference was observed among the five groups. For definition of groups, please see text.

Table 3

Function	Group	Times				
		1	2	3	4	5
PaO ₂ (mmHg)	A1	69.6 ± 5	111.9 ± 28	147.2 ± 41*	157 ± 42 [†]	116 ± 25*
	A2	78.6 ± 8		78.1 ± 8	82.7 ± 9	78.7 ± 14
	B1	68.8 ± 8	97.8 ± 17	146.5 ± 33*	156.6 ± 40 [†]	102.5 ± 13*
	B2	87.9 ± 19		82 ± 12	88.2 ± 10	86.7 ± 10
	C	81.3 ± 11 [‡]	144.8 ± 27 [‡]	208.7 ± 35 ^{**}	233.7 ± 37 ^{**†}	152.2 ± 31 ^{**}
SaO ₂ (%)	A1	94.2 ± 1.4	97.7 ± 1.3	98.6 ± 0.9*	98.9 ± 0.5 [†]	98 ± 1*
	A2	95.4 ± 1.3		95.3 ± 1.3	96 ± 1.2	95 ± 2.2
	B1	93.7 ± 2.1	97.1 ± 1.5	98.7 ± 0.5*	98.8 ± 0.5 [†]	97.4 ± 1*
	B2	96.2 ± 3.3		96 ± 1.6	96.8 ± 1.1	96.7 ± 1.1
	C	96.4 ± 1.3 [‡]	98.9 ± 0.3 [‡]	99.4 ± 0.2 ^{**}	99.6 ± 0.1 ^{**†}	99 ± 0.4 ^{**}
PaCO ₂ (mmHg)	A1	39.2 ± 4	40.1 ± 4	40.3 ± 4	41.2 ± 4	40 ± 5
	A2	40.9 ± 3		41.3 ± 4	41.1 ± 5	41.1 ± 5
	B1	39 ± 4	40.1 ± 5	41.6 ± 5	43.6 ± 6	43.8 ± 7
	B2	38.9 ± 4		40.8 ± 4	40.6 ± 5	38.5 ± 3
	C	35.9 ± 4	36.3 ± 6	37.5 ± 5	36.3 ± 4	35.6 ± 5

* $P < 0.05$, versus the previous time within each group; [†] $P < 0.05$, versus time 2 within each group; [‡] $P < 0.05$, versus groups A1 and B1 in the correspondent time. PaO₂, arterial oxygen tension; SaO₂, arterial

oxygen saturation; PaCO₂, arterial carbon dioxide tension. For a definition of the groups and times, please see text.

The patient breathing room air during the two manoeuvres (groups A2 and B2) showed a very slight, nonsignificant change in PaO₂ and SaO₂ at times 3, 4 and 5.

PaCO₂ remained stable, without significant change within each group at all times of the study.

The statistical analysis among the groups supplied with oxygen (A1, B1 and C) indicated significant higher values of PaO₂ and SaO₂ ($P < 0.05$) in group C when compared with groups A1 and B1 at the five different time points of the study, with no significant change for PaCO₂. The comparison between the groups breathing room air (A2 versus B2) showed no significant change in the three parameters

at all times. In patients in groups A2 and B2, SaO₂ was never below 93% during the two manoeuvres [5].

The respiratory rate was very stable, without significant change within each group throughout the study; however, it was significantly higher ($P < 0.05$) in group C versus the other four groups at all times (Table 4).

Discussion

The physiopathological modifications that occur in the respiratory system in the head-down position have been extensively studied [2,3,4,6]. Coonan and Hope [3], when analysing the cardiorespiratory effects of change in body position, concluded that the head-down position reduces

Table 4

Group	Time				
	1	2	3	4	5
A1	13.3 ± 1.9	13.2 ± 2.1	13.6 ± 2.6	13.6 ± 2.4	13.4 ± 2.5
A2	13.2 ± 2		13.4 ± 2	13.4 ± 2.4	13.3 ± 1.9
B1	13.7 ± 1.5	13.8 ± 1.8	14 ± 2.3	14 ± 1.8	13.8 ± 2.1
B2	13.4 ± 2		13.4 ± 2.6	13.4 ± 2.4	13.3 ± 2.5
C	18.9 ± 2.4*	18.5 ± 2.2*	18.7 ± 2.3*	18.7 ± 2.8*	18.8 ± 2.1*

* $P < 0.05$, versus all the other groups; no significant difference was found within each group. For explanation of the groups and times, please see text.

the FRC in the lung region near the diaphragm, which is compressed by the weight of the abdominal content, and increases the pulmonary blood volume in the dependent parts of the lungs under the effect of both gravity and the increase in cardiac output [7]. The result of these physiological changes can modify the ventilation-perfusion ratio and can interfere with oxygen uptake and carbon dioxide elimination [7,8]. The application of the drapes completely covering the face could interfere with respiratory gas exchange by creating a chamber of stagnating air, which might favour the rebreathing of the expired gases through a dead-space effect. This effect was only hypothesized, as we found no such confirmation in the literature. The purpose of this study was to investigate the influence of the two manoeuvres on the respiratory gas exchange in the cardiosurgical patient, and also to find a correlation between the respiratory gas exchange modifications and the preoperative function of the left ventricle.

On the basis of the results obtained in our study, we can confirm that the 30° head-down position, used to cannulate the internal jugular vein, does not influence respiratory gas exchange in coronary patients both with reduced or preserved preoperative LVEF if they were breathing oxygen at $F_iO_2 = 0.4$ or breathing room air. This correlation is supported by the fact that moving the patient from the head-down position while leaving the drapes in place did not significantly change PaO_2 or $PaCO_2$ in patients in these groups.

In the patients with end-stage heart disease, moving the patient from the head-down position was effective in significantly improving arterial oxygenation. This result leads us to deduce that in these patients the use of the head-down position can interfere with arterial oxygenation, reducing arterial oxygen tension. The pulmonary circulation of the patient with end-stage heart disease, altered by previous episodes of left ventricular decompensation, is probably more sensitive to the effects of the increased

intrathoracic blood volume, as happens in the head-down position, and this condition can lead to an increase in the intrapulmonary shunt fraction [9]. However, supplying these patients with oxygen at $F_iO_2 = 0.4$ while in the head-down position maintained PaO_2 and SaO_2 above the low safety limits.

We did not test the respiratory effects of the two manoeuvres in the patients with end-stage heart disease breathing room air, as we considered such a condition to be not safe enough in patients affected by important alterations of the cardiovascular function [10].

Another characteristic of the patients with end-stage heart disease is represented by the higher values of PaO_2 and SaO_2 reached at the five times of the study when compared with the same parameters in the coronary patients supplied with oxygen. The different drugs administered at the premedication time in the two groups can explain such behaviour. In fact, morphine may have depressed the respiratory function of the coronary patients more than did diazepam in the patients with end-stage heart disease [11,12]. This effect is supported by analysis of the results obtained at time 1: higher values of PaO_2 and SaO_2 , lower values of $PaCO_2$ and the higher respiratory rate in group C when compared with those of groups A1 and B1 may indicate superior ventilation in the patients with end-stage heart disease.

Considering the trend of arterial oxygenation, we can also deduce that the main factor responsible for the increase in PaO_2 and SaO_2 in all groups supplied with oxygen is the presence of the drapes completely covering the face. In these patients, the only contributing factor to the difference between time 4 and the basal time is the covering of the face by drapes; body position and inspiratory oxygen concentration were constant. This effect leads us to hypothesize that the drapes applied over the face may have facilitated the increase in oxygen concentration in the inspired gases by slowing down its diffusion into the room air. If this mechanism was responsible for the increase in arterial oxygenation, we could also expect an increase in $PaCO_2$ as a consequence of carbon dioxide increase in the air below the drapes, but this event did not happen. It is possible that carbon dioxide did not increase in the inspired gases because of its higher diffusion compared to oxygen through the drapes, as it occurs at the alveolar-capillary membrane [13], but we are unable to conclude this.

Furthermore, coronary patients not in the head-down position and breathing room air showed improved arterial oxygenation with the drapes applied over the face. However, the increase in PaO_2 and SaO_2 was smaller than that observed in patients supplied with oxygen, although the levels of arterial oxygen tension and saturation were still satisfactory.

Although the questions asked are not completely solved by this study, we conclude that the 30° head-down position and complete covering of the face by drapes (two manoeuvres that are frequently employed in anaesthesia, intensive care and emergency medicine during the insertion of the monitoring catheters) do not interfere with respiratory gas exchange and can be safely used in awake, premedicated coronary patients without respiratory disease. This applies whether they present a preserved or impaired LVEF and whether they breath oxygen at $F_iO_2=0.4$ or room air. In the patients with end-stage heart disease with no rest dyspnoea, the two manoeuvres can be safely employed if we supply oxygen at $F_iO_2=0.4$.

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