

A Five-day Orthostatic Training Program Improves Cardiovascular Response in Intensive Care Patients

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Abstract

Objective: To evaluate the cardiovascular response to passive orthostatic training.

Method: Intensive care patients were recruited. Patients in Control group underwent conventional physical therapy. Patients in the Training group additionally underwent daily assistive standing training with the use of an orthostatic bed for five days. All patients in the Training group were evaluated while on the orthostatic table (at rest for 10 minutes, at 75 degrees of inclination for 40 minutes and after returning to the supine position). Heart rate and mean arterial pressure were assessed at each stage. Both groups were assessed at baseline and after seven days.

Results: After the 5-day intervention patients from Control group had their mean arterial pressure decreased significantly (19 mmHg in average) when compared to baseline mean arterial pressure at the moment they had their body position elevated, with the worsening of postural hypotension in the following minutes, pattern which not found in the Training group patients.

Conclusion: A five-day orthostatic training in intensive care patients can be safely performed and improves cardiovascular response.

Keywords: Passive orthostatic training; Cardiovascular response; Critical care; Immobilization

cardiovascular response of critically ill patients admitted to the intensive care unit.

Introduction

On an intensive care unit (ICU) setting, decreased physical activity as a result of long periods of bed rest or inadequate positioning [1], corticosteroids and muscle relaxants use and need of mechanical ventilation [2] can lead to the development of neuromuscular, pulmonary and cardiovascular dysfunctions.

Possible consequences include; decrease in total blood volume, increase in heart rate (HR) at rest, orthostatic intolerance, probability of thromboembolism, atelectasis, pleural effusion, failure in mechanical ventilation weaning, oxygen desaturation, predisposition to pneumonia, decrease in muscles' strength, bone loss, loss in the vestibular system accuracy, excess morbidity and mortality, and increase of length of stay and of costs involved with hospitalization [3-5].

Early introduction of rehabilitation interventions [5] reduces clinical complications and length of stay, and improves self-esteem and quality of life of critical patients [6,7], as it minimizes the impact of immobilization [8].

The standing support system helps patients to sustain vertical position when they are unable to stand by themselves [9]. This paper aims to verify the effects of the standing support system in

Methods

The present study was performed as a feasibility trial to evaluate the effect of passive orthostatic training compared to regular training in an ICU setting. The inclusion criteria were: patients with clinical stability, over 18 years of age; and who failed to sustain standing position on their own. Failure to stand up was considered when patients had orthostatic hypotension (decrease in systolic blood pressure greater than 20 mmHg or a decrease in diastolic blood pressure greater than 10 mmHg within three minutes of standing when compared to sitting or supine position) [10].

Patients were excluded if the cause of orthostatic hypotension or inability to stand was related to dehydration, neurological disorders, instable cardiovascular disease, hemodynamic instability, and use of inotropic drugs, spinal trauma or instability, fracture of the lower limbs and/or contraindication of weight bearing.

Patients entered the Control group (CG) before the use of orthostatic table became a routine in the service. Training group (TG) corresponded to patients submitted to orthostatic table training. All patients, from both groups, were submitted to respiratory and motor physiotherapy in bed.

The evaluation of both groups was performed on the first assessment and on the seventh day, with the use of an orthostatic

motor bed (CARCI®) as follows: patients were placed on the orthostatic table in the supine position and were remained at rest for 10 minutes (stage 1); the orthostatic motor bed was then placed at 75 degrees of inclination for 40 minutes (stages 2, 3, 4 and 5-10 minutes each, with no difference in angulation). Finally, the orthostatic motor bed was then placed back at horizontal position (stage 6).

Heart rate and mean arterial pressure (MAP) were measured during all stages. The procedure was interrupted whenever clinical signs of intolerance were observed (respiratory frequency >45 rpm and/or use of accessory muscles; and/or MAP <60 mmHg, diastolic blood pressure >100 mmHg) [10].

Patients in CG were submitted to evaluation on the first day, then underwent conventional physical therapy during the following five days, and were reassessed on the seventh day. Those who were in TG also underwent conventional physical therapy in addition to assistive standing training for five days in a row, and were also reassessed on the seventh day.

Statistics

Demographic data is presented as mean and standard deviation. Statistical analyzes were performed with SPSS 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Due to the small number of cases, non-parametric tests were performed. The MAP and HR descriptive analysis is presented in median and interquartiles, as its dispersion measure. Pre and post values of BP and HR between stages in the same group were analysed with t-student, to dependent sample. Pre and post values of BP and HR at each stage between both groups were compared using the Wilcoxon nonparametric test with Monte Carlo simulation to 10.000 cases. Spearman correlation was performed to assess the relationship between MAP and HR at each stage. The adopted level of significance was 0.05. Graphics were performed with GraphPad Prism 4.00 for Windows and adjusted for visual reason (Figure 1).

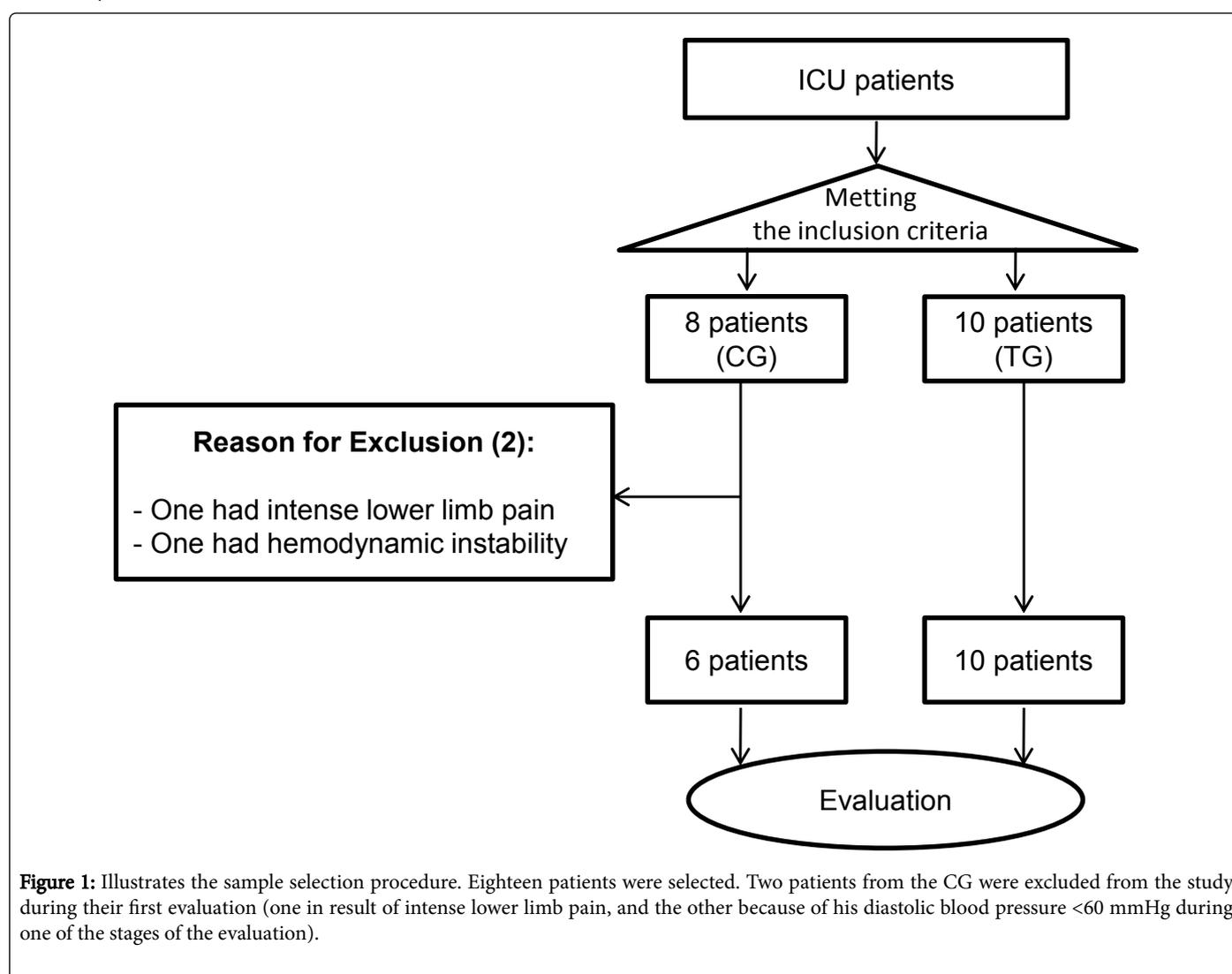


Figure 1: Illustrates the sample selection procedure. Eighteen patients were selected. Two patients from the CG were excluded from the study during their first evaluation (one in result of intense lower limb pain, and the other because of his diastolic blood pressure <60 mmHg during one of the stages of the evaluation).

Results

Data comparing CG and TG evidenced that TG patients improved their cardiovascular response. There were no withdraws during the

protocol, thus the study included sixteen patients, with no significant difference of age between groups ($p=0.38$). The CG had six patients (2 females) with 48.0 ± 17.6 years of age. Ten patients (3 females) with

51.5 ± 23.2 years of age were included in the TG group. The admission diagnoses are presented in Table 1.

MAP and HR before intervention, on the re-evaluation, after the 5-day intervention is shown in Table 2. Data is presented in their mean and confidence interval for better exposure.

Overall, in the TG, MAP had no significant difference among stages, during the first evaluation, and HR increased linearly up to 21% compared to rest (p=0.23). During the upright position, subjects' HR reached 80% of the training HR calculated with the use of the Karvonen formula [10].

Sample traits	CG	TG	Difference intergroup
	(6)	(10)	
Demographic data			
Age (years old)	48 ± 17.6	51.5 ± 23.2	NS

Male/female	4/2	7/3	NS
Diagnosis (Number (%))			
COPD	2(33.5)	5(50.0)	NS
Heart failure	2(33.5)	2(20.0)	NS
Trauma	1(16.5)	0(0)	NS
Pneumonia	1(16.5)	0(0)	NS
Sepsis	0	3(30.0)	NS

Table 1: Group traits according to diagnosis at intensive care unit admission.

Stage	TG				P value	CG				pvalor
	MAP		HR			MAP		HR		
	Before	After	Before	After		Before	After	Before	After	
1	90 (84-96)	90 (86-96)	80 (72-95)	89 (87-92)	0.04	90 (86-87)	110(93-112)	92(89-98)	92(88-100)	≤ 0.03
2	94 (84-103)	90 (85-106)	78 (72-84)	90 (81-94)	0.04	88 (76-118)	128(91-130)	73(70-76)	112(93-131)	≤ 0.03
3	106 (76-112)	96 (85-107)	83 (76-90)	92 (84-106)	NS	102 (77-122)	118(90-131)	72(67-79)	135(100-137)	≤ 0.03
4	102 (72-107)	92 (88-108)	80 (78-94)	95 (89-110)	NS	98 (72-111)	140(101-148)	105(81-121)	114(96-129)	≤ 0.03
5	100 (70-107)	91 (85-104)	85 (74-88)	108 (98-117)	0.04	97 (73-119)	137(95-146)	98(78-103)	116(108-129)	≤ 0.03
6	93 (88-96)	92 (88-95)	94 (79-92)	92 (84-98)	NS	86 (78-108)	119(95-123)	80(72-87)	102(96-112)	≤ 0.03

TG: Training Group; CG: Control Group; MAP: Mean Arterial Pressure (mmHg); HR-Heart Rate (bpm-no significant)

Table 2: Mean arterial blood pressure and heart rate before and after intervention (mean and confidence interval).

In the CG, MAP also showed no significant difference among stages. Similarly to the HR response in the TG, HR in subjects from the CG had 26% increase compared to the rest (p=0.38). Their HR also reached 80% of the training HR calculated with the use of the Karvonen formula [10].

For both groups, HR was not correlated to MAP on day one (TG: r=-0.51 with p=-0.14; CG: r=-0.29 with p=0.95).

On the re-evaluation, after the 5-day intervention, rest hemodynamic values showed that TG presented 12 mmHg lower MAP and 10 bpm lower HR than CG (p=0.033). Mean arterial pressure in the TG kept similar levels during all stages. Moreover, MAP was lower when compared to baseline (in stages 1, 2, 3 and 5). Heart rate presented no significant difference among stages and when compared to baseline. The maximal increase of HR was 7% on the last stage, compared to baseline (p=0.5).

Patients from CG, on the re-evaluation, after the 5-day intervention, had their MAP decreased significantly (average decrease of 19 mmHg) compared to baseline, now they had their body position first elevated, with the worsening of postural hypotension in the following stages (p<0.05). Their HR increased linearly as they remained on the orthostatic position, with a 27% of HR increase compared to baseline (p=0.03).

Heart rate did not correlate linearly with MAP, on the second evaluation for TG: R=0.29 with p=0.66. However, HR correlated inversely with MAP on the second evaluation for subjects from the CG (R=-0.67; p = 0.14 in stage 2; R=-0.88 p=0.02 in stage 4; R=-0.61; p=0.19 in stage 5 and R =-0.55; p=0.26 in stage 6).

Figure 2 shows the behaviour of the MAP and HR of TG and CG patients during the study period.

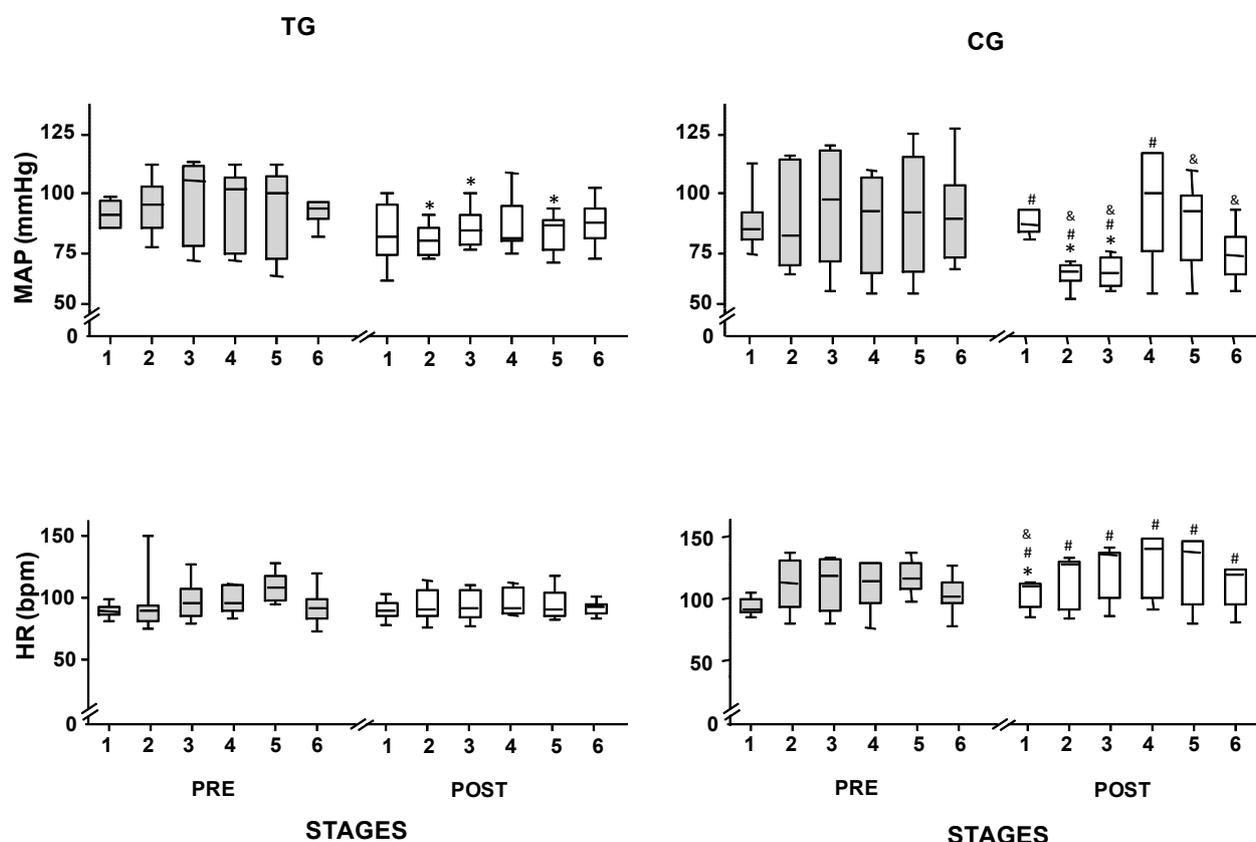


Figure 2: Mean arterial pressure and heart rate in the Control group and Training group. TG: Training Group; CG: Control Group; MAP: Mean Arterial Pressure; HR: Heart Rate. Corresponding to the MAP data: * $p=0.04$ compared to baseline correspondent variable in the same group. # $p=0.008$ between different stages (stage 1x stage 2; stage 1 x stage 3) in the same group. Monte Carlo analysis between groups at the same stage ($p=0.0001$; $p=0.006$; $p=0.003$ and $p=0.007$, respectively). Corresponding to the heart rate data: * $p<0.03$ compared to baseline correspondent variable in the same group. # $p=0.02$ between different stages (stage 1x stage 2; stage 1 x stage 3; stage 1 x stage 4; stage 1 x stage 5, stage 1 x stage 6) in the same group. &Monte Carlo analysis between groups at the same stage ($p=0.03$).

Discussion

This trial was able to show the feasibility of training to prevent postural hypotension with the use of assistive orthostatism.

As we found in this current study, there are reports that postural hypotension usually happens in the first minute of tilt [10-13] but it could also occur up to after three minutes of elevation [14-16].

The BP decrease during the standing position is due to a combination of both reduction of systolic pressure [17] and total peripheral resistance [18]. Blood pressure decrease was observed with decrease of the MAP at the beginning of stage 2, and remained low in stage 3 in both groups. Although this current study used similar angulation as most other studies [12,19-24] a couple of previous trials contradicted the effect of tilt in MAP. One study indicated that MAP average did not change significantly because the diastolic BP was increased (from 77 to 84 mmHg) [19] and another study showed the lack of changes in MAP was due to peripheral sympathetic denervation [24].

A trial with 66 patients, suffering from several diseases (orthostatic hypotension, neurogenic syncope, tachycardia), evidenced that the time of standing on the motor bed has more significant impact than the actual angle, comparing 60 to 90 degrees.

After 20 minutes at three different angles, the response was the same: a drop of BP and an increase in HR by more than 70% [25]. Another study guaranteed that 30 minutes of tilt and an angle of 60 degrees represent the best available resource to investigate the blood pressure fall [21,23]. Our study also evidenced that BP pressure drop occurred during the first 20 minute period.

The average fall in the MAP obtained in this study (19 mmHg) was different from the one obtained in other studies, which showed an average fall of 25 mmHg [15,18] what can be explained by the difference in samples sizes and clinical data. Another trial showed the average lowering in the MAP of 17%, similar to ours [18]. Time of recovery of blood pressure was found to be significantly lower in younger patients [15,26]. As the literature suggests, it is reasonable to conclude that daily orthostatic position training minimizes the drop on the BP [27].

Another study showed that cardiac patients have their circulatory response decreased after 20-minute of passive orthostatism at 70 degrees, after being under transthoracic impedance analysis, because they had a decrease in stroke volume and cardiac index, and a smaller increase in total vascular resistance in patients in the control group [17]. This was not found in our study because both groups had the same total number of subjects suffering from cardiac diseases, which did not influence final results.

The mean current elevation in systolic blood pressure of 15 and 5mmHg in the control and the training was different from the average of 9mmHg found in two other studies [24,26].

Our HR findings are similar to a recent report in the literature, although the authors had submitted patients to a lower increase in tilt, when compared to our study [27].

Reasons that explain the immediate increase in HR after being held on vertical position found in the present study are several: it can be explained due to withdrawal of vagal tone evoked by changes in baroreceptors pressure located in the aorta and carotid sinus [28] by the mentioned decrease in stroke volume [19,29], and by a higher amount of norepinephrine release and lower-pressure pulse when placed in the vertical position, also present in subjects without disease [19].

Although the time of HR recovery to baseline values in both groups was not measured, TG presented an earlier return to baseline HR after the intervention when compared to CG. Another study evidenced a delay of 15 to 25 minutes for the return of pre-tilt cardiac output values [19]. The five untrained days could have favored the deconditioning of patients in the control group, leading to maintenance of high HR when in the upright position. As this was not found in the training group, this may be explained by possible improvement in cardiac tolerance [3]. The five days of training in the motor bed prevented orthostatic hypotension and promoted a faster recovery of HR when returned to horizontal position. Thus, orthostatic training in subjects referred to ICU can be performed in order to reduce complications related to the immobilization period and facilitate patients' recovery.

The current study has some limitations, as the small number of patients, age range, and gender and diagnosis differences. There was also no control of the time from admission to the ICU and admission in the study. Perhaps a longer period of follow up and more patients could show different results. Another limitation of the study was that it does not answer if the intervention was able to reduce length of stay in the ICU or length of stay in the hospital of these patients.

Conclusion

A five-day orthostatic training in intensive care patients can be safely performed and improves cardiovascular response.

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