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Cardiorespiratory consequences to hobble restraint

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Kardiorespiratorische Folgen der Schutzfixierung

Zusammenfassung. Mechanische Schutzfixierung wird weiterhin bei agitierten, sich selbst und andere gefährdenden psychiatrischen Patienten in der Initialphase der Notfallbehandlung angewendet, besonders wenn Patienten durch die Polizei ins Krankenhaus gebracht werden. Plötzliche Todesfälle während dieser Schutzfixierung sind vorgekommen. Die kardiorespiratorischen Folgen einer Schutzfixierung in aufrechter wie auch in am Bauch liegender Position wurde bei sechs männlichen Probanden in einer randomisierten Crossover-Untersuchung erhoben. Ergebnisse: Nach Schutzfixierung in aufrechter Position kam es zu keiner signifikanten Veränderung der untersuchten kardiorespiratorischen Parameter. Nach Schutzfixierung in am Bauch liegender Position kam es zu einer Verminderung der FVC um 39,6%, das FEV1 um 41%, das ETCO2 stieg um 14,7%, die Herzfrequenz verminderte sich um 21,3%, der systolische Blutdruck verminderte sich um 32,3%, der diastolische Blutdruck verminderte sich um 26,1% und das Herzminutenvolumen verminderte sich um 37,4% (P für alle Werte < 0,01). Conclusion: Schutzfixierung in Bauchlage führt zu einer dramatischen Verschlechterung der kardiorespiratorischen Gesamtsituation. Aufrechte Haltung und kurzfristige Kontrolle der Vitalparameter ist daher beim Transport von schutzfixierten Patienten unerläßlich.

Schlüsselwörter: Schutzfixierung, kardiorespiratorische Folgen, Lungenfunktion.

Summary. Mechanical restraints in agitated, violent psychiatric patients are still sometimes in use in the initial phase of emergency treatment, especially when patients are taken to hospital by law enforcement. Sudden death has occurred in persons in hobble restraint. Cardiopulmonary response to prone or upright hobble restraint for three minutes was investigated in six male volunteers in a randomised crossover trial. Results: No change was observed in the investigated cardiopulmonary parameters after hobble restraint in the upright position. After hobble restraint in the prone position, mean forced vital capacity decreased by 39.6%, mean forced exspiratory volume by 41%, mean end-tidal carbon dioxide increased by 14.7%, mean heart rate decreased by 21.3%, mean systolic blood pressure decreased by 32.3%, mean diastolic blood pressure decreased by 26.1% and mean cardiac output decreased by 37.4% (P for all reported changes < 0.01). Conclusion: Hobble restraint in the prone position leads to a dramatic impairment of hemodynamics and respiration. Upright position and frequent control of vital parameters are necessary to prevent a possibly fatal outcome in persons in hobble restraint.

Key words: Mechanical restraint, cardiorespiratory response, pulmonary function.

Introduction

Mechanical restraints in agitated, violent psychiatric patients are still sometimes in use in the initial phase of emergency treatment, especially when patients are taken to hospital by law enforcement. A number of recent case reports have drawn attention to the possible hazards of mechanical restraint [4, 9]. Sudden death has occurred in persons in hobble restraint under the observation of paramedics [11]. Forensic literature explains these deaths by asphyxia due to mechanical restraint [1, 10]. No trials have been reported so far on the acute cardiorespiratory response to hobble restraint.

Methods

The study was performed as a randomised crossover trial. Six male volunteers, aged 25 to 35 years, mean weight 77.2 ± 11.3 kg, mean height 1.84 ± 0.09 m, took part after informed consent. All probands were healthy non-smokers and took no medication. No subject was under- or overweight. Subjects were randomised to prone or upright hobble restraint for three minutes. Ankles and wrists were tied behind the subjects' back; subjects either kneeled upright or were placed in a prone position. The following cardiopulmonary measurements were performed before mechanical restraint while the subjects were sitting upright and after three minutes of mechanical restraint in the respective position. Forced vital capacity (FVC) and forced expiratory volume (FEV_1) were measured by spirometry (Vitalograph Ltd, Buckingham, UK), arterial oxygen saturation (SpO_2) by pulse oxymetry, end tidal carbon dioxide ($ETCO_2$) by capnometry and heart rate by ECG (all on a HP CMS patient monitor system, Hewlett Packard, Palo Alto, California, USA). Non-invasive measurement of blood pressure and cardiac output was performed using Portapres® (TNO, Amsterdam, Netherlands), which is a new non-invasive device. The Portapres® measures arterial blood pressure continuously and computes cardiac output from an analysis of the pulse curve [7, 12].

Statistics

Direct comparison of each cardiopulmonary parameter before and after hobble restraint in the respective position was

Table 1. Cardiopulmonary parameters of six subjects before and after three minutes of prone hobble restraint

	Rest	3 min prone hobble restraint	Diff	95% CI	p
FEV_1 (litres)	3.93 ± 0.47	2.32 ± 0.34	1.61	1.35 to 1.87	< 0.01
FVC (litres)	4.67 ± 0.80	2.82 ± 0.30	1.85	1.11 to 2.58	< 0.01
RR_{sys} (mmHg)	125.83 ± 7.81	85.17 ± 15.66	40.67	28.33 to 53.01	< 0.01
RR_{dia} (mmHg)	73.33 ± 5.16	54.17 ± 10.65	19.17	9.03 to 29.31	< 0.01
HF/min	81.5 ± 6.92	64.17 ± 8.57	17.33	12.75 to 21.92	< 0.01
CO (litres)	5.35 ± 1.16	3.35 ± 0.91	2.00	1.46 to 2.54	< 0.01
S_pO_2 (%)	97.5 ± 1.52	97.67 ± 0.82	−0.17	−1.2 to 0.87	n.s.
$ETCO_2$ (mmHg)	35.17 ± 1.17	40.33 ± 3.33	−5.17	−8.42 to −2.1	< 0.01

performed by paired t-test. Data are expressed as means and 95% CI of the mean paired differences are reported. Probability levels less than 0.05 were considered significant.

Results

No significant change in the investigated cardiopulmonary parameters was observed after hobble restraint in the upright position. Results after hobble restraint in the prone position are shown in detail in Table 1. Mean FVC decreased by 39.6%, mean FEV_1 by 41%. There was no change in SpO_2, but mean $ETCO_2$ increased by 14.7%. Mean heart rate decreased by 21.3%, mean systolic blood pressure decreased by 32.3%, and mean diastolic blood pressure decreased by 26.1%. Mean cardiac output decreased by 37.4% (P for all reported changes < 0.01). The possibility of any effect of test order or treatment carry over was tested using the baseline readings before both conditions of mechanical restraint [6]. No significant effects were found with regard to all cardiopulmonary parameters.

Discussion

Mechanical restraint is not purely of historical interest in psychiatry. Even in the times before modern antipsychotic and sedative drug therapy were available, psychiatrists considered mechanical restraint to be, at best, a necessary evil and not part of a therapeutic regimen [2]. In a recent Danish study mechanical restraint constituted 0.3% of the entire duration of psychiatric hospitalisation in acute admission wards, 45% of these patients were not restrained by a waist belt alone, but with the use of wrist and ankle cuffs, the number of patients in hobble restraint is not reported. Mean length of mechanical restraint was 4.3 hours [3]. A doctor was not present in 49% of the cases when mechanical restraint was applied. No data have been reported so far on the incidence of mechanical restraint in preclinical transport. Case reports give evidence of hobble restraint in patients with acute intoxication due to alcohol, amphetamines and cocaine, whereby only paramedics and law enforcement personnel were present at the time of restraint [11].

Three minutes of hobble restraint in the prone position were followed by a dramatic decrease in cardiopulmonary parameters in our study. Although there have been reports of sudden, unexpected deaths in persons in hobble restraint during law enforcement transport, no clinical data on cardiorespiratory changes during hobble restraint have been reported so far. Forensic literature explains these deaths by position asphyxia, which occurs when the body position causes inability to breathe or airway obstruction. Our respiratory data, i.e., the increase in $ETCO_2$, and the decrease in FVC and FEV_1 after three minutes of hobble restraint in the prone position support this hypothesis. No change occurred in SpO_2; we suppose that this is due to the very short time of mechanical restraint in this study as compared to the situation in practice. The changes in respiratory parameters are induced by the restriction of movement of the chest and possibly the diaphragm [11]. In contrast to previous reports, the changes in the hemodynamic parameters are equally dramatic. The decrease of blood pressure and cardiac output can be explained by the elevation of intrathoracic pressure, leading to an impairment of systemic venous return and resulting in a right and left ventricular preload reduction [5]. The decrease of heart rate can be explained by an activation of the Bezold Jarisch reflex [8].

For the safety of patients, agitated and violent individuals are sometimes physically restrained in hospital and during ambulance transport to hospital. Our data clearly indicate, that hobble restraint in the prone position leads to a dramatic impairment of hemodynamics and respiration. The clinical relevance of our data can be summarized as follows: if mechanical restraint can not be avoided, the vital parameter must be controlled frequently. In the case of hobble restraint, the upright position is mandatory to prevent a possibly fatal outcome. Adequate training of medical and law enforcement personnel is necessary.

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