International Journal of Cardiology xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Short communication

# Upside-down position for the out of hospital management of children with supraventricular tachycardia☆

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ARTICLE INFO

*Article history:*
Received 29 May 2017
Received in revised form 25 October 2017
Accepted 31 October 2017
Available online xxxx

*Keywords:*
Pediatrics
Arrhythmia
Emergency medicine

ABSTRACT

*Background:* The upside-down position is a little known modified Valsalva manoeuvre (VM). The aim of this study was to investigate the safety and the efficacy of the upside-down position for the treatment of paroxysmal SVT in children.
*Methods:* Twenty-four paediatric patients followed for SVT were enrolled. The patients were assigned (1:1) to a standard VM or to an upside-down position at the first episode of SVT at home. If no cardioversion occurred, a second attempt was undertaken with the other VM. At the patient's first relapse, the intervention protocol was applied in the opposite order at home.
*Results:* The upside-down position compared to standard VM reached 67% vs 33% rate of cardioversion at a first attempt, followed by 50% vs 0% rate of cardioversion in patients who had failed the first attempt. After having reversed the order of intervention in case of SVT recurrence, we recorded 67% vs 25% and 71% vs 42% success rates in favour of the upside-down position. There were no adverse events.
*Conclusion:* The upside-down position was safe and tended to be more effective than standard VM for out of hospital SVT treatment. Doctors and parents should be more aware of this effective but overlooked manoeuvre.


## 1. Introduction

Supraventricular tachycardia (SVT) is the most common arrhythmia in children; the estimated prevalence varies from 1 in 250 to 1 in 1000 children with two peaks, one within the first year and the other after 6–7 years of age. The first episode of SVT occurs in the first month of life in about 40% of patients, while in >50% it occurs within the first year of life [1]. Atrioventricular re-entry tachycardia is the most frequent (over 70% of cases), followed by ectopic atrial tachycardia, atrioventricular nodal re-entry tachycardia, atrial flutter and junctional ectopic tachycardia. SVTs are usually paroxysmal and occur at rest, although stress can be a trigger for some episodes. Clinical presentation varies according to the age of the patient: heart failure is quite common under one year of age (about 30%) while palpitations, chest pain, syncope, fatigue and dizziness are common in older children [2]. In infants, there is spontaneous resolution in about 90% of cases with SVT recurrence in up to one-third at a mean age of 8 years. The prognosis for most patients with SVT is excellent, with limited mortality [1].

Recent European guidelines for paediatric arrhythmias recommend using vagal manoeuvres for acute termination of narrow complex tachycardia in the stable patient prior to the administration of antiarrhythmic drugs.

Diving reflex and gastric tube insertion in infants or carotid sinus massage, Valsalva manoeuvre (VM) and handstand in older children are widely accepted as effective in a considerable proportion of patients [3]. The VM, firstly described by Antonio Maria Valsalva in 1704 as a means of expelling pus from the middle ear, is traditionally performed by expiring against a closed glottis to increase intrathoracic pressure, thereby triggering baroreceptor activity and increased vagal tone, in order to terminate the established re-entry circuit [4].

Moreover, some modified VM techniques are well known to be able to further increase systemic venous return and vagal tone [5–7], even though only one recent randomized controlled trial demonstrated their superiority compared to traditional VMs in an adult population with SVT [8]. In a paediatric setting, one of the reported modified VMs

*Abbreviations:* SVT, supraventricular tachycardia; VM, Valsalva manoeuvre.

☆ All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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https://doi.org/10.1016/j.ijcard.2017.10.120
0167-5273/

is the upside-down position which can be achieved by turning younger children upside-down, or asking heavier and more cooperative children to do a handstand (assisted by health care professionals). The rationale of the procedure is quite similar to other vagal manoeuvres, even though a further increased venous return could improve the rate of cardioversion to sinus rhythm. Data regarding the safety and the efficacy of this procedure are limited, consisting of only a few case reports [9–11].

In this paper we report the first pilot study to investigate the safety and the efficacy of the upside-down position for the acute treatment of paroxysmal SVT at home in a cohort of 24 children.

## 2. Patients and methods

This study was promoted by the Paediatric Cardiology and Grown Up Congenital Heart Unit, S. Orsola–Malpighi University Hospital, Bologna, Italy.

Informed consent was obtained for each patient. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.

We included patients aged 1–18 years followed at the paediatric arrhythmology outpatient clinic with SVT defined by a regular, narrow complex tachycardia with QRS duration < 0.12 s on ECG and/or for the demonstrated sensitivity to adenosine diagnosed by a paediatric cardiologist with >15 years of experience in paediatric arrhythmia management. In practice, we included AV-node dependent arrhythmias, on which the vagal reflex could act. Exclusion criteria were age > 18 years or <1 year (to avoid cerebral circulation problems), unstable patients with hypotension (defined according to reference values adjusted for age) [12] or those who required immediate cardioversion, ECG diagnosis of automatic atrial tachycardia, permanent form of junctional reciprocating tachycardia, atrial fibrillation or flutter, underlying congenital heart disease and contraindications to VM/upside-down position (aortic stenosis, retinopathy, glaucoma) or inability to perform them (relevant musculoskeletal or pulmonary disease). We selected patients and families that seemed very reliable. We did not give the parents any monitoring equipment since, during follow-up visits, they had been taught to identify the heart rate through palpation of the brachial or carotid pulse and with a stethoscope, and to correctly perform the vagal manoeuvers.

A total of 24 patients were enrolled in the study (mean age 7 ± 3.8 years; 15:9 = F:M). Sixteen patients were diagnosed with atrioventricular re-entry tachycardia (6 patients with ECG manifested delta wave and 10 with occult accessory pathway), 4 patients with atrioventricular nodal re-entry tachycardia and in the remaining 4 patients ECG features were consistent with both SVT types mentioned above (electrophysiological study not yet performed). Eight out of 24 patients were under pharmacological prophylaxis for SVT: 4 with Flecainide, 2 with Sotalol and 2 with Diltiazem. Patients were then divided into 2 groups, the VM group and the upside-down (UD) group, with an equal distribution of type of SVT and any antiarrhythmic treatment [Table 1].

Patients were randomly assigned (1:1) to a standard VM (VM group) or to an upside-down position treatment (UD group) at the first episode of SVT that occurred at home. Standard VM was performed by the semi-recumbent patient blowing into a 10 mL syringe to move the plunger for 15 s as this technique has proved to be effective in generating the recommended 40 mm Hg of intrathoracic pressure [13]. The upside-down position was achieved by manually flipping children <30 kg or uncooperative ones upside-down or asking children >30 kg who were able to perform a handstand to do so. In both cases, the position was maintained for 30 s. Patients were then returned to a supine position for cardiac rhythm re-assessment. If no cardioversion occurred, a second attempt was undertaken with the other VM. In the case of failure of both procedures, the patients were taken to the hospital as indicated by the protocol and drug treatment was performed according to current paediatric guidelines at the Paediatric Cardiology Department [3]. At discharge, each participant continued the cardiologic follow-up at the paediatric arrhythmology outpatient clinic.

At the patient's first relapse, the intervention protocol was applied in the opposite order at home. Patients who firstly performed the standard VM were assigned to the upside-down position and vice versa. If no cardioversion occurred, a second attempt was undertaken with the other VM.

**Table 1**
Patients characteristics.

| | UD group | VM group |
|---|---|---|
| Number of patients | 12 | 12 |
| Mean age | 6.9 ± 2.9 | 7.2 ± 4.5 |
| Females | 7 | 8 |
| AVRT | 7 | 9 |
| AVNRT | 2 | 2 |
| Both types | 2 | 2 |
| Pharmacological prophylaxis | 3 (2 Flecainide 100 mg/m$^2$; 1 Sotalol 80 mg/m$^2$) | 5 (2 Flecainide 100 mg/m$^2$; 1 Sotalol 80 mg/m$^2$; 2 Diltiazem 5 mg/kg die) |

AVRT, atrioventricular reentrant tachycardia; AVNRT, atrioventricular nodal reentrant tachycardia.

### 2.1. Statistical methods

Statistical significance of the difference between VM and UD manoeuvre rates of cardioversion was investigated using Fisher's exact test. A $p$ value < 0.05 was considered significant.

## 3. Results

In the VM group, the standard VM was effective in 4/12 patients (33%) at the first episode of SVT; in the other 8 patients, the subsequent upside-down position was effective in 4 cases (50%).

On the other hand, in the UD group the upside-down position was effective in terminating the SVT in 8/12 patients (67%) (33% vs 67%; $p = 0.1$) while, at the second attempt with standard VM, none returned to sinus rhythm ($p = 0.2$) without the use of drugs. According to the study design, the intervention protocol was applied in the reverse order.

In the VM group, the upside-down position was effective in 8/12 patients (67%) at the first episode of SVT, and only 1/4 of the non-responders (25%) returned to sinus rhythm with a standard VM.

In the UD group, the standard VM was effective in 5/12 patients (42%) (67% vs 42%; $p = 0.2$) and, after a second attempt with the upside-down position, we recorded a successful cardioversion in 5/7 patients (71%) (25% vs 71%; $p = 0.2$).

There were no adverse events.

## 4. Discussion

Supraventricular tachycardias can have a dramatic impact on children and their families. Although there are very effective drug and electrical therapies, it is extremely important to stop the arrhythmia immediately with non-drug manoeuvers and, if possible, to avoid hospitalization and venipuncture.

This is a very important aspect in children since psychological stress may lead to relapses and decrease the response to therapy. During our over 20 years' experience, we have always explained vagal manoeuvres to the patients, and for the last three years also through a tutorial video (https://youtu.be/ohw_YILF9_E). The parents told us that, of all the vagal manoeuvres, the upside-down position worked much better, that it was performed as a game and thus was the one most appreciated by children. The key point is that vagal manoeuvres work much better if they are performed before the adrenergic tone rises, which is why they work more often at home than in the emergency room, which is usually a long time after the SVT occurred.

The upside-down position for SVT treatment was safe in an out of hospital setting, in particular when the parents' compliance was screened during outpatient follow-up examinations.

As a matter of fact, our experience showed a trend towards greater effectiveness of this modified version of the VM than the standard manoeuvre, without reaching statistical significance: 67% vs 33% rate of cardioversion between the two methods at a first attempt, followed by 50% vs 0% rate of cardioversion in patients who had failed the first attempt and, after reversing the order of intervention in the case of SVT recurrence, we recorded 67% vs 25% and 71% vs 42% success rates, always in favour of the upside-down position, in both therapeutic interventions. Furthermore, no correlation was found between the effectiveness of vagal manoeuvers and the age of the patients, maybe due to the small size of the population. These results thus suggest a similar superiority of modified VM compared to the standard procedure, as recently shown in an adult setting by Appelboam et al. [8]. We would also like to stress that this experimental protocol was performed out of hospital, showing satisfactory safety and efficacy. The upside-down position is, however, disregarded and only occasionally used owing to a lack of clear data. Among the study limitations we acknowledge that the sample size was relatively small and the results should thus be confirmed in a larger population. In addition, the patients enrolled in the study were followed only in a tertiary referral centre, and a possible selection bias

Please cite this article as: G. Bronzetti, et al., Upside-down position for the out of hospital management of children with supraventricular tachycardia, Int J Cardiol (2017), https://doi.org/10.1016/j.ijcard.2017.10.120