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ORIGINAL ARTICLE

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Cardiac pacing in cardioinhibitory syncope in children

Christian Paech MD | Franziska Wagner MD | Sebastian Mensch MD | Roman Antonin Gebauer MD

Department for Pediatric Cardiology, University of Leipzig—Heart Center, Leipzig, Germany

Correspondence
Christian Paech, MD, Department for Pediatric Cardiology, University of Leipzig—Heart Center, Strümpellstr. 39, 04289 Leipzig, Germany.
Email: christian.paech@med.uni-leipzig.de

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Abstract

Introduction: Reflex vasovagal—or cardioinhibitory syncope is known to be a major cause of recurrent syncope in children. The mechanism of vasovagal syncope (VVS) is an interaction between a vagally mediated bradycardia or asystole and a more or less manifest vasodilatory component. Although pacing is not advisable as a standard approach in patients with VVS, it remains a treatment option of last resort in exceptionally severe cases, or patients with contraindication or refractoriness to drug therapy and life style changes. To effectively avoid VVS in these patients, the pacemaker has to both prevent bradycardia and to compensate for the vasodilatory component. Therefore, this study aimed to evaluate a simple pacemaker setting (VVI pacing with hysteresis) with the potential to prevent VVS in affected children.

Methods: Clinical data of patients, who were presented to the Department for Pediatric Cardiology, Heart Center Leipzig, in the period of 2001-2017 for cardiac pacemaker implantation for cardioinhibitory syncope or pallid breath-holding spells, were collected retrospectively.

Results: Eleven pediatric patients, median age 2.7 (0.8-17) years, were included. Pacemaker settings are depicted. In 10 out of 11 patients, an entire abolishment of syncope could be achieved (P = .002).

Conclusion: The presented VVI pacing with hysteresis seems to be a promising pacemaker setting in pediatric patients with cardioinhibitory syncope who need a pacemaker. Unnecessary ventricular stimulation is effectively avoided, while cardiac output is preserved during cardioinhibition, by providing a sufficient paced heart rate, compensating for the often present vasodilatory component.

KEYWORDS
cardiac pacing, cardioinhibitory syncope, children, pacemaker, syncope

1 | INTRODUCTION

Reflex vasovagal syncope (VVS) or cardioinhibitory syncope is known to be a major cause of recurrent syncope in children. The mechanism of loss of consciousness in these patients is often an interaction between a vagally mediated bradycardia or asystole and a more or less manifest vasodilatory component that leads to a drop in blood pressure. Presenting with a similar mechanism are pallid breath-holding spells in young children. Mostly, drug-based or change-of-lifestyle-options are effectively preventing syncope. The use of cardiac pacemakers (PM) remains a controversial topic and should only be considered in very severe cases.[1,2] This is reflected by a class IIb indication in current adult as well as pediatric guidelines.[3,4] As no deaths are reported for VVS or pallid breath-holding spells, they are considered as benign diseases and PM implantation is sensibly reserved as a treatment of last resort.[5,6] Yet, despite the benign nature of both diseases, a sufficient therapy is crucial because affected patients and their families often suffer a significant psychological burden by repetitive syncope. Furthermore,

there is a significant risk of traumatic injury in case of cardioinhibitory syncope and there is no structural data available, that frequent asystole does not impair brain or mental development. Therefore, it seems to be crucial that in those very rare cases, when a PM implantation cannot be prevented by conservative treatment options, the patient can be provided with an effective PM setting. Yet, the optimal pacemaker settings remain unclear. Typically, affected children do not need pacing for most of the time, but need a relatively fast pacing rate at the time of vasovagal reflex. To effectively avoid syncope in these patients, the pacemaker has to fulfill the challenging task to prevent bradycardia, and to compensate the vasodilatory component of the reflex loop, which requires a relatively high pacing rate to provide the extra amount of cardiac output. Therefore, this study is aimed to evaluate our single-center experience with a simple pacemaker setting that has the potential to prevent syncope in this subgroup of affected children.

2 | METHODS

2.1 | Patients

Clinical data of patients, who were presented to the Department for Pediatric Cardiology, Heart Center Leipzig, in the period of 2001-2017 for cardiac pacemaker implantation for cardioinhibitory syncope, were collected retrospectively. Cardioinhibitory syncope or pallid breath-holding spells fulfilling the internal criteria for pacemaker implantation were defined as syncope with documented asystole of more than 10 seconds and failure to conservative treatment options including beta-blocker, increased fluid, and salt intake. Symptoms, age at first consultation, as well as surgical records, clinical follow-up data and cardiac pacemaker follow-up data were reviewed. Long-term follow-up data were obtained from patient records and correspondence with parents. Written consent of all patients/parents was obtained.

2.2 | Statistics

Data analysis was performed using SPSS statistics V.25 software (IBM, Armonk, New York). Patients were compared using paired Student *t* test. A *P* value of <.05 was considered statistically significant.

3 | RESULTS

3.1 | Patients' characteristics

Patients' characteristics are reported in Table 1.

TABLE 1 Patients characteristics. Data are displayed as median (range)

Number of patients	*n* = 11
Gender	5 male 6 female
Age at implantation (y)	2.7 (0.8-17)
Height at implantation (cm)	90 (70-156)
Weight at implantation (kg)	11.7 (7.4-54)
Max. duration asystole (s)	14 (11-21)
Average number of syncope before PM implantation	9 (1-30)
Follow up (y)	6.8 (0.6-9.6)

3.2 | Pacemaker settings

Table 2 summarizes pacemaker settings and outcome after pacemaker implantation. All patients included in this study had an implanted epicardial single chamber cardiac pacemaker. There were no perioperative complications reported. All pacemakers were designed by St. Jude Medical (St. Paul, Minnesota). Almost all patients received the same initial pacemaker setting after implantation. This included a VVI mode at a rate of 100 bpm with a hysteresis programmed to 70 bpm in infants, 50 bpm in children younger than 5 years of age, and 40 bpm in children >5 years of age. The manufacturer-specific search algorithm was programmed to the shortest possible search interval for redetection of the patients' intrinsic ventricular rhythm. Whenever syncope occurred, despite PM implantation, the device was reprogrammed by increasing the hysteresis by 10 bpm.

3.3 | Outcome after placement of a cardiac pacemaker

Table 2 outlines the major results from cardiac pacing in our study group. A significant reduction in VVS after PM implantation and optimization of PM settings was seen (*P* = .002). It has to be mentioned that 4 out of 11 patients needed reprogramming of the PM. This finally led to an entire abolishment of VVS, except for patient one. Worth mentioning, this patient suffered from an additional neurologic disease ie, Arnold-Chiari malformation with occlusive hydrocephalus requiring ventriculoperitoneal liquor drainage, suggesting a more complex form of a syncope than the typical VVS. In addition, the pacemaker settings provide a constantly low ventricular pacing share. There were no pacemaker-related complications reported during follow-up.

4 | DISCUSSION

The aim of this study was the evaluation of our single-center experience with the pacemaker settings of VVI pacing with hysteresis. This study demonstrated that pacemaker placement and programming to VVI pacing with hysteresis was associated with resolution of syncope in 10 of 11 patients and reduced events in the single patient who continued to have episodes.

Apart from the fact that pacing is not advisable as a standard approach in patients with VVS, it remains an accepted therapeutic strategy in exceptionally severe cases, as well as in cases with

TABLE 2 Pacemaker settings and outcome after pacemaker implantation

Patient number	Age (y)	Height (cm)	Weight (kg)	Max. asystole (s)	Nr. of syncope before PM	PM setting 1	Nr. of syncope after PM	PM setting 2	Nr. of syncope after adjust. PM setting 1	PM setting 3	Nr. of syncope after adjust. PM setting 2	Ventricular stimulation (%)
1	0.8	70	9	12	30	VVI 110, hysteresis 70	10	VVI 110, hysteresis 50	10	VVI 110, hysteresis 50	10	5.7
2	1.3	72	7.4	15.5	1	VVI 100, hysteresis 50	0					<1
3	4.9	116	21	11.2	20	VVI 100, hysteresis 50	0					1.7
4	2.7	90	11.7	15	10	VVI 100, hysteresis 50	0					<1
5	7.1	125	25.3	13	8	VVI 100, hysteresis 40	0					<1
6	17	156	54	12	5	VVI 100, hysteresis 40	1	VVI 100, hysteresis 50	0			<1
7	1.3	79	8.9	15	30	VVI 100, hysteresis 50	5	VVI 100, hysteresis 60	2	VVI 100, hysteresis 70	0	<1
8	1.8	85	11.4	21	15	VVI 100, hysteresis 50	0					<1
9	1.6	80	10	11	3	VVI 100, hysteresis 50	0					<1
10	3.9	102	15.7	15	5	VVI 90, hysteresis 45	5	VVI 100, hysteresis 50	0			<1
11	7.8	129	26	14	9	VVI 100, hysteresis 40	0					<1

Abbreviations: PM, pacemaker; Nr. of syncope, number of syncope.

contraindication or refractoriness to drug therapy and lifestyle changes. Doubtless, the threshold for pacing should remain high and a PM implantation should only be considered after all available conservative and pharmacological options are exhausted and appropriate discussions with the patient/parents regarding the risks of a pacemaker took place.

Yet, whenever a pacemaker is placed in this group of patients, especially in children, the use of optimal pacemaker settings is crucial for an effective prevention of VVS.[7] There have been several multicenter studies both unblinded and prospective, double-blinded, evaluating the effectiveness of cardiac pacing in adult patients with VVS.[8-11] The unblinded studies show a significant improvement of pacing regarding the prevention of VVS, but the double-blind studies fail to give clear evidence. All but two studies evaluated dual chamber (DDD) pacing with rate response. The only exceptions were two studies, which reported on simple dual chamber (DDI) backup pacing, at a rate of 40 bpm, with expectedly lower effectiveness than the DDD pacing strategy.[12] When looking at pediatric data, effectiveness of DDD as well as VVI backup pacing could be shown in one randomized, blinded single-center study including 12 children with reflex anoxic seizures.[13] The main difference between single chamber versus dual chamber pacing was that DDD pacing resulted in a more effective suppression of presyncopal events, whereas both pacing systems resulted in an equal reduction of syncope compared to placebo. These findings underline the importance of choosing an optimal pacemaker setting independently from the use of a single or dual chamber device. The strategy reported in the current study, offers the possibility of a low pacing amount using a hysteresis, as low as 40 bpm in children, but instead providing an instant increase in cardiac output with an interventional rate of 100 bpm. The optimal timing of the onset of stimulation seems crucial for an effective prevention of VVS. This can be seen from the four patients who showed recurrent syncope despite PM implantation. After adaptation of the hysteresis to higher heart rates and thereby earlier onset of stimulation, three out of those four patients showed complete abolition of their syncope (See Table 2). It has to be mentioned that the presented pacemaker setting (VVI pacing with hysteresis) also provides the possibility to increase the interventional rate whenever failure to prevent syncope by pacing is suspected to be due to limited compensation for vasogenic component of VVS. The approach in our center is first to adapt the hysteresis to higher heart rates and only secondly to increase interventional rate. Furthermore, there is only one pacemaker lead used, which means an assumingly lower lead-related complication rate, which was one of the most often reported complications during pacing in this group of patients reported in the VPS II study.[2] After all, the presented studies either refer to relatively complex pacemaker programming, involving closed-loop mechanisms, or very simple PM settings, that would only prevent severe bradycardia or asystole. These pacing strategies may show satisfactory results in selected patients; mainly those with primary bradycardia or asystole, but only very limited and suboptimal results in vasogenic hypotension. As our data imply that the presented pacing strategy seems to be effective in selected patients. The main advantages of our pacing strategy are the easy pacemaker programming, the presumably high effectiveness and the necessity of only one pacemaker lead, an aspect that is especially important in young patients who are probably dependent on lifelong pacing and therefore perseverance of vascular access that may be damaged during lead replacement.

5 | CONCLUSION

The presented VVI pacing with hysteresis seems to be a promising pacemaker setting in pediatric patients with cardioinhibitory syncope who need a pacemaker. Unnecessary ventricular stimulation is effectively avoided, while cardiac output is preserved during cardioinhibition, presumably by providing a sufficient paced heart rate, compensating for the often present vasodilatory component.

6 | LIMITATIONS

The presented data are a single-center experience and may be prone to a systematic bias. The presented study was not aimed to address the indication for cardiac pacing in patients with VVS or breath-holding spells, as this topic remains controversial and cannot be substantially enhanced with data from a retrospective, single-center study. The lack of a control group is an important limitation in this retrospective study, which cannot exclude the potentially significant influences of placebo effect and natural history on patient outcomes.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

C. Paech and S. Mensch performed data collection and drafted the manuscript. F. Wagner and R. Gebauer thoroughly revised and approved the manuscript.

ORCID

Christian Paech http://orcid.org/0000-0001-9676-8994

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