World Federation of Pediatric Intensive & Critical Care Societies

Cardiac arrhythmias in the PICU

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No conflicts of interest to declare

Introduction

- ✓ Cardiac rhythm disturbances are commonly observed in critically ill children.
- ✓ A given arrhythmia may constitute the primary disease process, occur secondary to another disorder, or represents a complication of management.

Introduction

- ✓ Optimal evaluation and management of arrhythmias in the critical care setting include:
  - Prompt haemodynamic stabilisation of the patient.
  - Use of modalities immediately available at the bedside.
  - Concurrent identification and correction of predisposing or causative factors.

Outline

- ✓ Definition and etiology of arrhythmias
- ✓ Arrhythmias in congenital heart diseases
- ✓ Management of arrhythmias in the unstable patient..
- ✓ Temporary pacing in PICU
- ✓ Arrhythmias in ostensibly healthy patients
- ✓ Arrhythmias during tracheal intubation

Consensus definitions

An arrhythmia is defined as "any cardiac rhythm other than the normal sinus rhythm. Such a rhythm may be either of sinus or ectopic origin, and either regular or irregular. An arrhythmia may be due to a disturbance in impulse formation or conduction, or both".

WHO/ISC Task Force. Definition of terms related to cardiac rhythm. Am Heart J 1978; 95: 796–806.

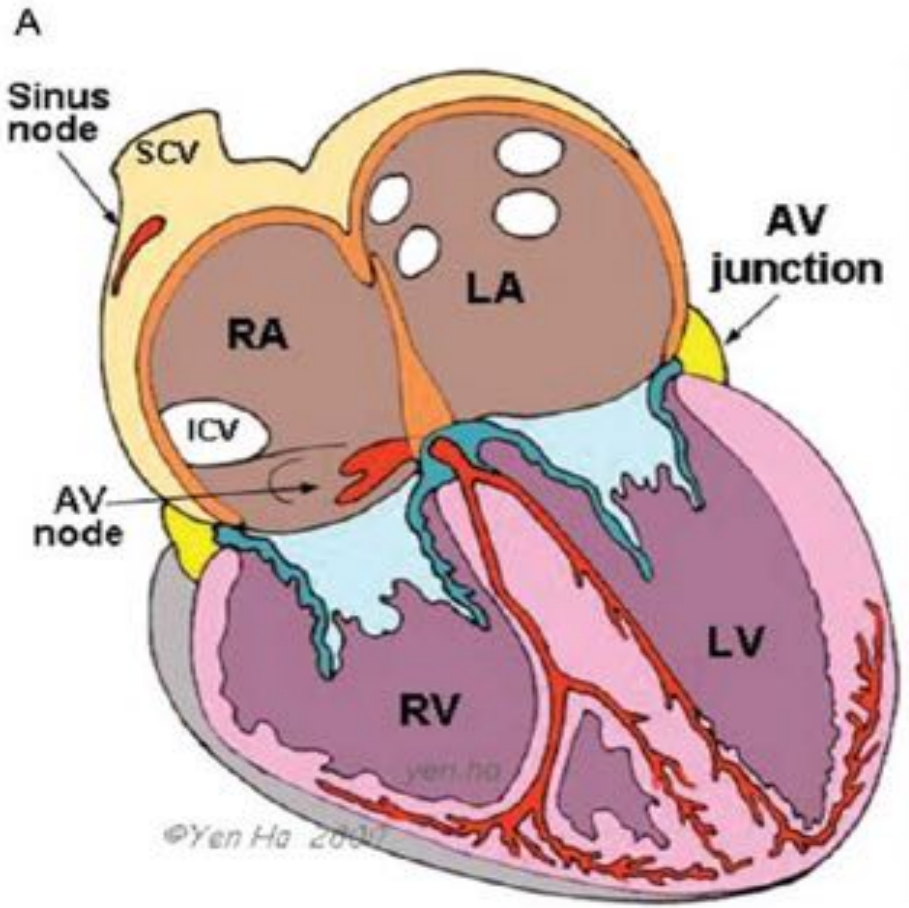
Electrocardiographically

- **Arrhythmias can be characterized as:**
  - **Bradycardia**
    - Sinus node bradycardia
    - Atrioventricular (AV) block
  - **Extrasystoles**
    - Supraventricular
    - Ventricular
  - **Tachycardia**
    - Supraventricular
    - Ventricular

Conceptual approach to arrhythmias

- Location
- Mechanism
- Duration
- Etiology

“Anatomical” classification of arrhythmias



- Atrial
- Junctional
- Ventricular
- Atrioventricular

J. Brugada *et al.* Europace (2013) **15**, 1337–1382

Mechanisms

- Reentrant (e.g. macro-reentrant tachycardia)
- Focal (e.g. automatic or micro-reentrant tachycardia)

Reentry mechanisms may account for more than 80% of clinical arrhythmias

Temporal descriptors of Arrhythmias

- **Non-sustained arrhythmias**
  - Duration of less than 30 seconds
- **Sustained arrhythmias**
  - Last for greater than 30 seconds or require immediate termination due to hemodynamics compromise
- **Frequency of occurrence**
  - Paroxysmal, recurrent, chronic recurring or permanent.

Etiology of Arrhythmias

- **Non-Iatrogenic**
  - Ischemic
  - Scar-related (fibrosis..)
  - Metabolic
  - Infectious
  - Multi-factorial
- **Iatrogenic**
  - Post-procedural
  - Mechanical
  - Ischemic
  - Metabolic
  - Infectious
  - Multi-factorial

Deal et al: Arrhythmic complications
Cardiol Young 2008; 18(Suppl. 2): 202–205

Risk factors for cardiac arrhythmias in children with congenital heart disease after surgical intervention in the early postoperative period

Joanna Rękawek, MD,[a] Andrzej Kansy, MD,[b] Maria Miszczak-Knecht, MD,[a] Małgorzata Manowska, MD,[c] Katarzyna Bieganowska, MD, PhD,[a] Monika Brzezinska-Paszke, MD,[a] Elżbieta Szymaniak, MD,[a] Anna Turska-Kmieć, MD,[a] Przemysław Maruszewski, MD,[b] Piotr Burczyński, MD, PhD,[b] and Wanda Kawalec, MD, PhD[a]

J Thorac Cardiovasc Surg 2007;133:900-4

- **Pathophysiologic causes of early postoperative arrhythmias**:
  - surgical injury caused by myocardial incision or cannulation
  - sutures affecting function of the AV conduction system
  - rapid changes of intracardiac pressures caused by volume and pressure fluctuations.
  - ...

TABLE 1. Potential risk factors for arrhythmias and perioperative details

	Arrhythmic group	Non-arrhythmic group	*P* value
Age (mo)	18.74, 95% CI (84-29.1), SD ± 39.04	31.23, 95% CI (26.8-46.3), SD ± 47.7	.0041
Body weight (kg)	8.96, 95% CI (5.9-12.0), SD ± 11.53	12.27, 95% CI (10.8-13.7), SD ± 13.53	.0078
Aristotle Basic Score (402 patients)	7.8, 95% CI (7.3-8.3), SD ± 1.9	6.22, 95% CI (6.0-6.4), SD ± 2.14	.000001
CPB time (299 patients)	169.1, 95% CI (150.1-188.2), SD ± 69.2	128.7, 95% CI (111.8-145.6), SD ± 134.9	.000001
Aortic crossclamp time (294 patients)	82.6, 95% CI (72.2-92.9), SD ± 37.1	53.6, 95% CI (49.3-57.9), SD ± 34.2	.000001
DHCA time (38 patients)	29.0, 95% CI (16.6-41.4), SD ± 19.6	20.4, 95% CI (13.7-27.1), SD ± 16.6	.24
IPPV time (h)	163.0, 95% CI (105.0-221.0), SD ± 218.6	76.2, 95% CI (45.5-106.9), SD ± 289.6	.000001
ICU stay (d)	10.7, 95% CI (6.9-14.6), SD ± 14.6	5.1, 95% CI (3.7-6.5), SD ± 12.9	.000001
Hospital mortality	9.26% (5/57)	2.6% (9/345)	.035

Values are presented as mean, 95% CI, and SD. *CPB*, Cardiopulmonary bypass; *DHCA*, deep hypothermia and circulatory arrest; *IPPV*, intermittent positive pressure ventilation, *ICU*, intensive care unit; *CI*, confidence interval; *SD*, standard deviation.

J Thorac Cardiovasc Surg 2007;133:900-4

- **Arrhythmias can result from perturbations of other organ systems, such as:**
  - Renal failure or diarrhoea with electrolyte disturbances
  - Gastroesophageal reflux or myocardial infarction resulting in vagotonia and bradycardia
  - Pain releasing cathecolamines → tachycardia

Deal et al: Arrhythmic complications
Cardiol Young 2008; 18(Suppl. 2): 202–205

- **Arrhythmias can produce dysfunction in other organ systems, due to hemodynamic compromise or embolic phenomena:**

  - Hypotension from tachycardia or bradycardia may cause decreased cardiac output, poor perfusion and organ dysfunction.

  - Intracavitary thrombus formation from a persistent atrial arrhythmia may result in systemic or pulmonary embolisation.

Deal et al: Arrhythmic complications
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Arrhythmias in the PICU

- **Rapid assessment of haemodynamic stability** is mandatory, including:
  - Level of consciousness
  - Ventilation
  - Tissue perfusion
  - Blood pressure and other vital signs
- **If time allows:**
  - Acid-base balance, electrolytes..
  - Serum lactate, mixed venous oxygen saturation, etc.

Arrhythmias in the PICU

- If the patient is sufficiently stable, therapy may be deferred until the arrhythmia can be more precisely characterized:
  - EKGs, Trans-esophageal EKG,
  - Cardiologist, Ecocardiography, ..
- Potentially life-threatening arrhythmias may require acute interventions:
  - Drugs
  - Cardioversion, Defibrillation
  - Temporary pacing
  - ECMO

Clinical case

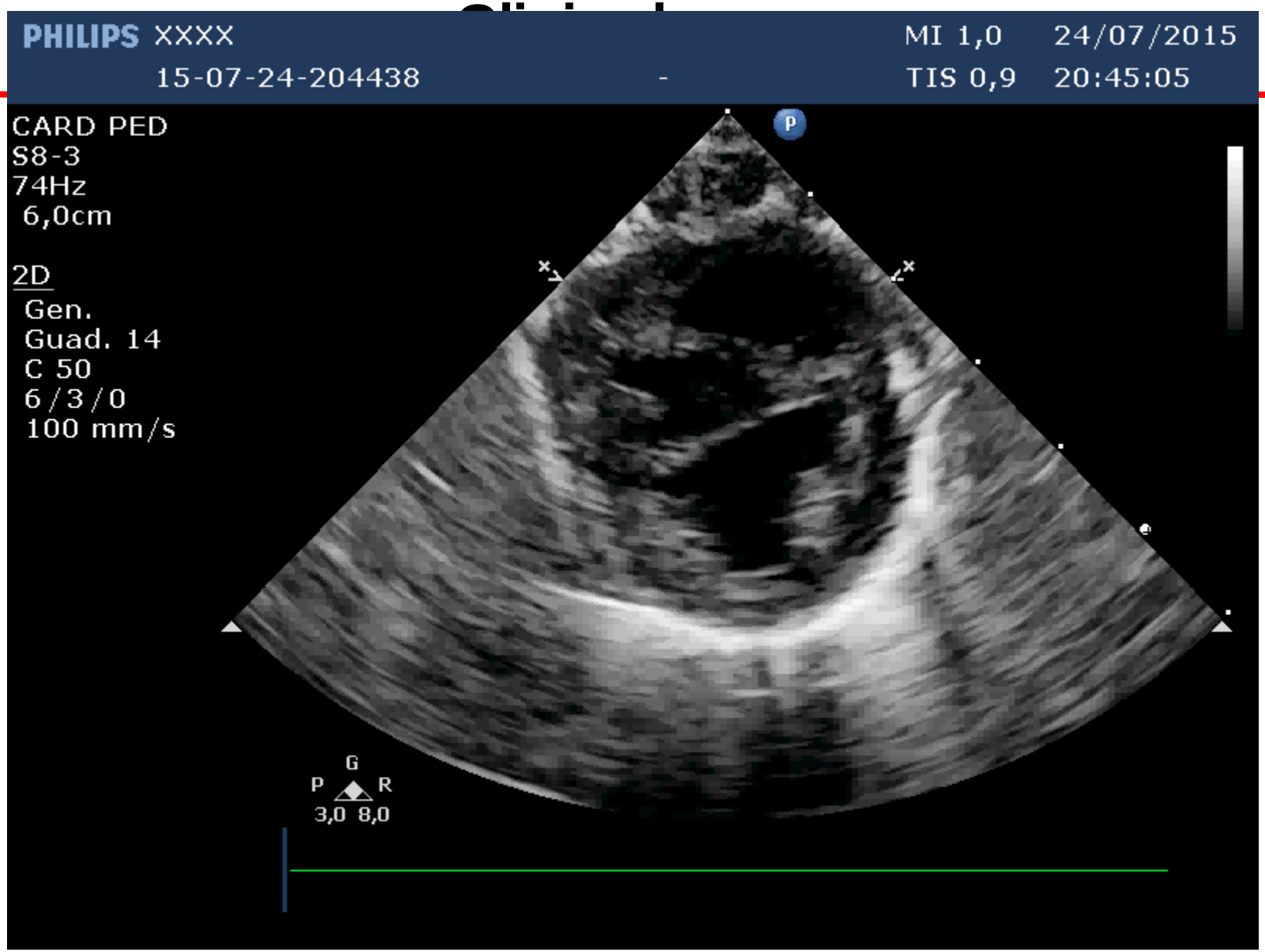
- Term baby, normal perinatal transition. Not feeding well at 25 days of life..
- Diagnosis of PSVT (paroxysmal supraventricular tachycardia) in a paediatric ED. Treated with amiodarone, with no success. Transferred to our unit.
- On arrival, 270 bpm, still compensated, but in few hours severe myocardial disfunction due to incessant tachycardia, despite:
  - Diving reflex, adenosine, cardioversion, amiodarone, metoprolol...

Clinical case

- A 25-day-old boy, previously healthy.....:

Clinical case

- A 25-day-old boy, previously healthy.....: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  - Divin… …darone, m…

Temporary pacing in PICU

Pacemaker therapy of postoperative arrhythmias after pediatric cardiac surgery

Peter Skippen, MBBS, FJFICM, FANZCA, FRCPC, MHA; Shubhayan Sanatani, MD, FRCPC; Norbert Froese, MD, FRCPC; Robert M. Gow, MB, BS, FRACP, FCSANZ, MedStats

(Pediatr Crit Care Med 2010; 11:133–138)

Temporary pacing in PICU

- Most common arrhythmias post congenital cardiac surgery involve either rate or conduction abnormalities.

- Thus, temporary pacemaker systems are a common form of electrical therapy in the postoperative period.

Temporary pacing in PICU

Table 1. Temporary pacemaker lead options

Type	Leads	Generator
Temporary epicardial	Placed at surgery, through skin, adherent to epicardium	External, temporary device or stimulator
Temporary transcutaneous	Adhesive pads placed on skin	Defibrillator with external pacing capability
Temporary transvenous	Balloon electrode through venous sheath[a]	External, temporary device or stimulator
Temporary esophageal	Esophageal electrode placed behind left atrium	External, temporary device or stimulator

(Pediatr Crit Care Med 2010; 11:133–138)

Basic temporary pacemaker function

The three main functions of the system are:

- Pacing
- Sensing
- Timing

Sensing concept

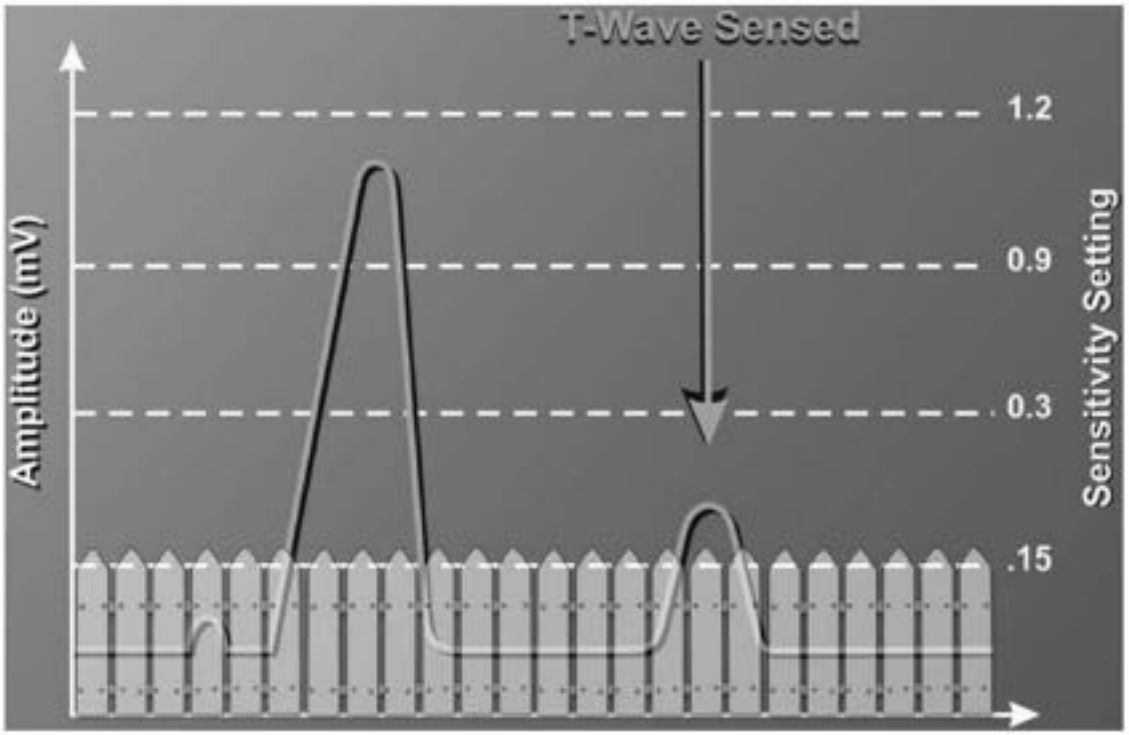


Figure 1. Diagrammatic representation of sensing concept. The higher the sensitivity setting (fence height) the taller the impulse peak has to be so it will be seen over the fence. If the sensitivity setting (fence height) is higher than the peak of the impulse it will not be seen (sensed).

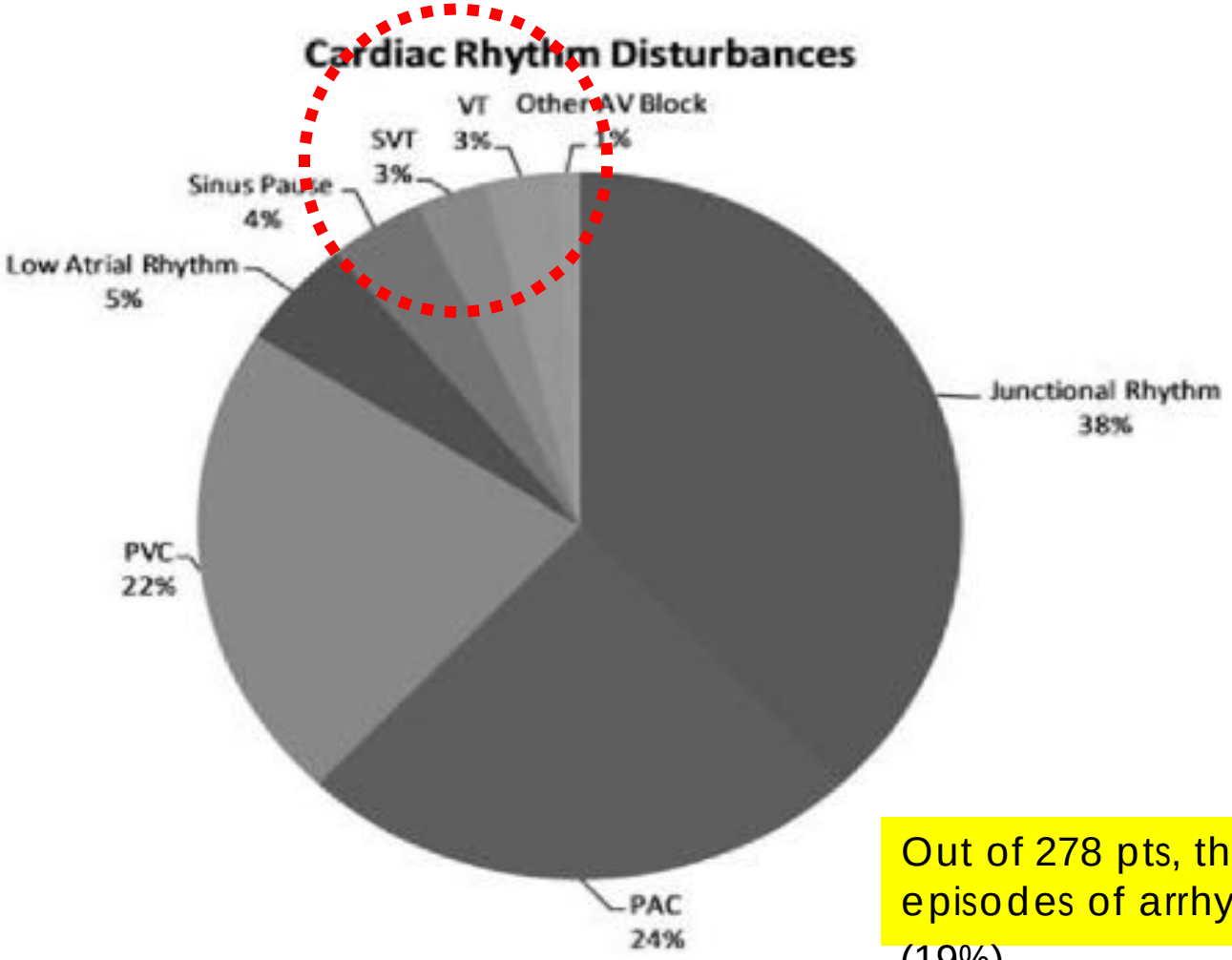
(Pediatr Crit Care Med 2010; 11:133–138)

Pacemaker Wire Removal...!!

- The wires are removed by constant gentle traction.
- If they cannot be removed easily by traction, they should be pulled as far as is felt safe and cut as close to the skin as possible, allowing the cut ends to retract.
- Bleeding of short duration from chest drains can be expected. There is a small risk of tamponade. (anticoagulation should be held before wire removal)
- There is no evidence that retracted wires cause any harm.

Skippen *et al*. Pediatr Crit Care Med 2010;11:133-138

Arrhythmias in the paediatric intensive care unit: a prospective study of the rates and predictors of arrhythmias in children without underlying cardiac disease



Out of 278 pts, there were 97 episodes of arrhythmia in 53 patients (19%).

Figure 1.

Cardiac rhythm disturbances. PACs = premature atrial contractions; PVCs = premature ventricular contractions; SVT = supraventricular tachycardia; VT = ventricular tachycardia.

Of the **six tachyarrhythmias,** four were related to **placement or migration of central venous lines** and two occurred during **aminophylline infusion.**

11-month-old boy with viral bronchiolitis, during aminophylline i.v. infusion (serum drug level below therapeutic range)

Figure 2.

Telemetry finding in an 11-month-old boy with bronchospasm and acute respiratory failure due to viral bronchiolitis. The tracing demonstrates sinus rhythm with a premature ventricular contraction (PVC), a ventricular couplet, and a 4-beat run of VT at a rate of 250 bpm.

The Effect of Atropine on Rhythm and Conduction Disturbances During 322 Critical Care Intubations*

Peter Jones, BChir, PhD[1,2]; Stéphane Dauger, MD, PhD[2,3]; Isabelle Denjoy, MD[4]; Nathalia Pinto da Costa, MD[2]; Corinne Alberti, MD, PhD[5,3,6]; Rym Boulkedid, PhD[3,7]; Mark J. Peters, FRCPCH, PhD[1]

(*Pediatr Crit Care Med* 2013; 14:e289–e297)

Objectives: Our objectives were to describe the prevalence of arrhythmia and conduction abnormalities before critical care intubation and to test the hypothesis that atropine had no effect on their prevalence during intubation.

Design: Prospective, observational study.

Setting: PICU and pediatric/neonatal intensive care transport.

Subjects: All children of age less than 8 years intubated September 2007–2009. Subgroups of intubations with and without atropine were analyzed.

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- There was a statistically higher prevalence of abnormal rhythms and conduction abnormalities during intubation **without atropine [26.5%] versus with atropine [4.5%];** OR, 0.14 [95% CI, 0.06–0.35], $p < 0.001$).

Figure 2. The distribution of arrhythmias according to groups of lowest heart rate during intubation showing increasing frequency of arrhythmia and conduction abnormalities as the heart rates fall. The mean heart rates for those who did and did not receive atropine are shown with SD bars.

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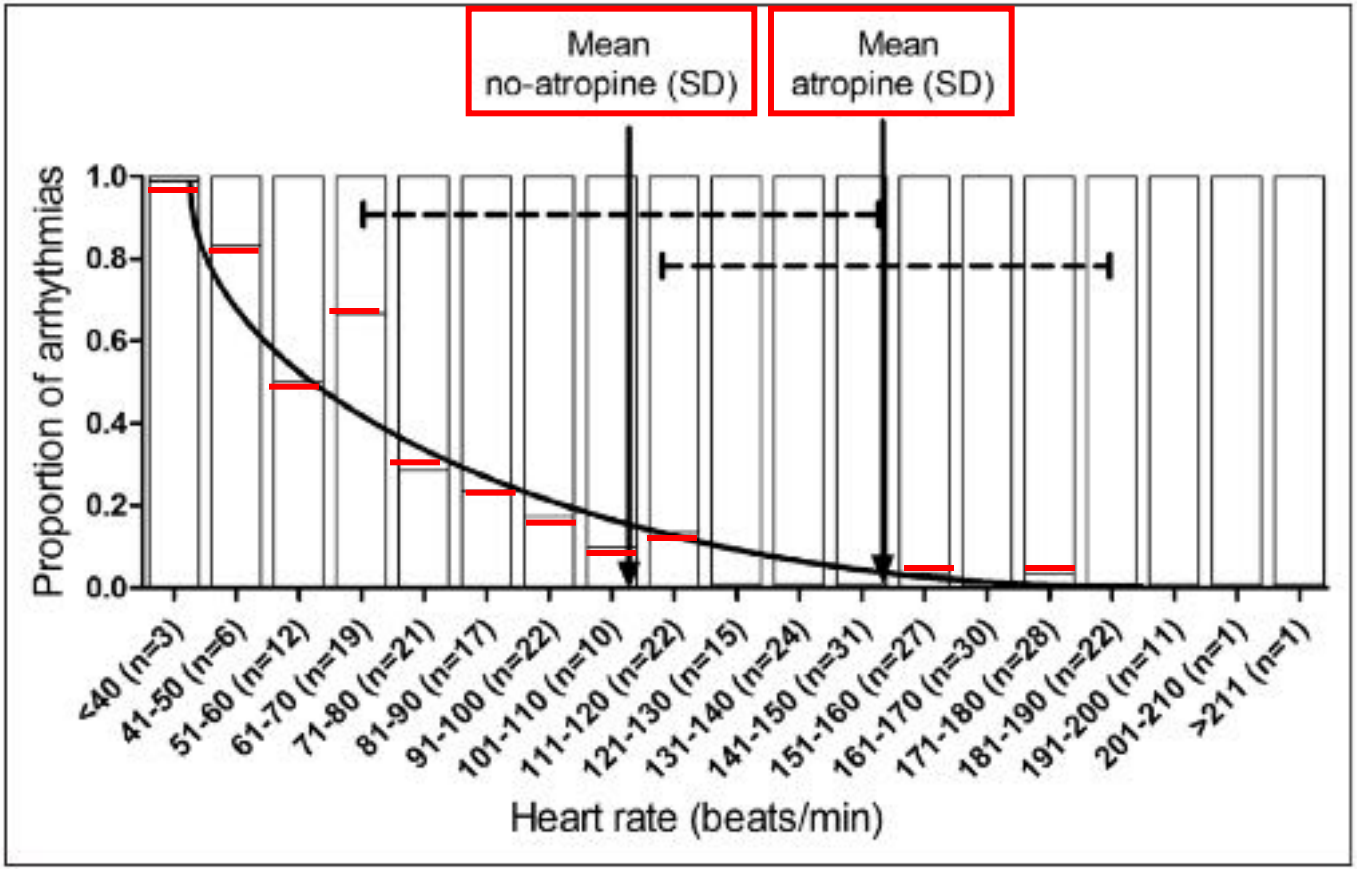

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Conclusions: Atropine significantly reduced the prevalence of new arrhythmias during intubation particularly for children over 1 month of age, did not convert sinus tachycardia to ventricular tachycardia or fibrillation, and may contribute to the safety of intubation.

8th World Congress on Pediatric Intensive and Critical Care

5-8 June, 2016 | Toronto, Canada

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❖ Thanks!

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