The Chest Xray and Electrocardiogram Roentgen/Einthove

The State of Their Art
Photograph of the bones in the fingers of a living human hand. The third finger has a ring upon it. W. K. Rontgen 1896
Experimental X-Ray Digital Detector for Investigation of Paintings

Radiological investigations constitute a fundamental tool for investigation of the inner structure of works of art.
Chest X-ray in Congenital Heart Disease

• Age and sex
• Right/left orientation
• Positions and malpositions -- above and below the diaphragm, thoracic and abdominal situs
• The bones
• Extrapulmonary soft tissue densities
• Intrapulmonary soft tissue densities – vascular and parenchymal
• The great arteries and great veins
• The atria
• The ventricles or ventricle
Xrays Should be Read, Not Looked At
Positions and Malpositions

Above and below the diaphragm. Thoracic and abdominal *situs.*
Transverse Liver
Asymmetric Right & Left Bronchi
Symmetric Right Bronchi.
Bilateral Trilobed Lungs.
Right Isomerism.
Symmetric Left Bronchi, Bilateral Bilobed Lungs, *Left Isomerism*
The Spleen.
The Body’s Only Unilateral organ.
Right Isomerism
No Left Side, No Spleen
Asplenia

Howell Jolly Bodies
Bilateral Left-sidedness
Polysplenia

Normal Spleen Plus
Accessory Spleens
Einthoven W. Über die form des menschlichen neurosurg.
Pflugers Arch 1895
Many brilliant minds have contributed to the development of electrocardiography as a clinical science. The early history (1900-1945) was dominated by Professor Willem Einthoven in the Netherlands, Sir Thomas Lewis in England and Dr. Frank N. Wilson in the United States. These three pioneers laid the foundation for modern electrocardiography.

Charles Fisch, The ECG Centennial
The Electrocardiogram

• P wave -- direction, morphology, duration, rhythm.
• PR interval -- duration.
• QRS -- duration, axis, direction of depolarization, amplitude, morphology.
• ST Segment -- deviation, morphology.
• T wave -- direction, morphology, amplitude, QT interval.
• U wave,
The Sinus Node
Junction of a Right SVC and a Morphologic Right Atrium
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Left Isomerism. Bilateral SVC’s. No RSVC/RA Junction. No Sinus Node
No Sinus Node. No Sinus Rhythm
Misplacements of the Heart

The heart may be congenitally misplaced in various ways, occupying either an unusual position within the thorax, or being situated external to that cavity.

Thomas B. Peacock 1858
The Egyptians believed that the heart was the seat of personal and moral integrity. If the heart were not in its right place, the individual would be beside himself.
Where is the Heart?
Ectopia Cordis
What Side Are You On?
Situs Inversus With Dextrocardia
Now What Side Are You On?

The Hemidiaphragm Levels
Left of Center.
Congenital Complete Absence of the Pericardium
Catamenial Pneumothorax

Recurrent pneumothorax that coincides with the menstrual cycle, described by Maurer in 1958, called catamenial pneumothorax by Lillington in 1972.
The Bones
A. Reynaud
1828

Bilateral Collaterals
Where are the collaterals?
Where is the coarctation?
Where is the rib notching?
Obstructed Left Subclavian
Unilateral Collaterals
Unilateral Notching
Absent Left Subclavian. Absent Left Brachial Pulse. Unilateral Notching.
Cheaper by the Dozen
Absent 12th Rib
Down Syndrome
Intrapulmonary Soft Tissue Densities: Vascular/parenchymal
Increased Pulmonary soft Tissue Densities
Where is the Shunt?
The Answer is Chrochetage
Sinus arrhythmia in children with atrial septal defect: An analysis of heart rate variability before and after surgical repair

Secundum ASD
Before and After Closure
SVC Sinus Venosus ASD
Absent Sinus Node
Absent Sinus Rhythm
Where is the Shunt?
Vectorcardiogram
Ostium Primum ASD
Extreme Left Axis Deviation
AV Septal Defect
The Atria
Ebstein’s, Pulmonary Atresia, Intact Ventricular Septum
Congenital Left Axis Deviation

- Wolff-Parkinson-White type B (isolated)
- Type B WPW with Ebstein’s anomaly
- Anomalous origin of LCA from pulmonary trunk
- Tricuspid atresia
- Congenitally corrected transposition
- Single ventricle (morphologic LV)
- Atrioventricular septal defect
- Double outlet right ventricle with infracristal VSD
Bland White Garland
Left Coronary Artery from Pulmonary Trunk
LAD, LVH, Deep Narrow Q Waves
“LVH“ is Hypoxemic Hyperplasia
Left Axis Deviation
Single Ventricle, LV Morphology
Outlet Chamber Non-Inverted
Non-Inverted Outlet Chamber --- LAD
Fallot

DORV Infracristal VSD,PS
DORV PS

Initial Force Remnant of LAD

Fallot
Congenital Deafness with Cardiac Arrhythmias: The Jervell and Lange-Nielsen Syndrome
A dog’s Life.
Coupled Rhythms
A Duet

Played by two hearts beating as one.
Coupled Rhythms
Coupled Hearts
Time Has A Way of Assigning Value

The chest X-ray and scalar ECG remain invaluable cornerstones in the clinical appraisal of congenital heart disease. The are not precision guesswork. They are here to stay.
The X-ray and Electrocardiogram

Fiscal Rationale

Relative Costs:

1) PA/Lateral Chest X-ray -- $191.00
2) Electrocardiogram -- $172.49
3) Echocardiogram -- $1,647
4) Cardiac MRI -- $2,431
5) Right/Left cardiac catheterization -- $8,000
Thank You
I shall focus on two aspects of this topic:
1) Unusual or atypical arrhythmias.
2) The signal averaged electrocardiogram
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The Electrocardiogram

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A dog’s Life.
Coupled Rhythms
In the 1970’s, Michael B. Simson at the University of Pennsylvania developed the signal averaged ECG to identify the slow conduction substrates of reentry. An arrhythmogenic substrate usually localized to the ventriculotomy scar where it can be localized and eliminated by surgery.
970’s, Michael B. Simson at the University of Pennsylvania, developed the signal average slow conduction substrates of reoperative arrhythmogenic substrate in the ventriculotomy scar where it occurred and eliminated by radiofrequency. Modern advances permit confident interpretation of ECG’s despite post-ventriculotomy...
The Signal Averaged Electrocardiogram for Detection of Post-ventriculotomy Late Potentials of Reentrant Monomorphic Ventricular Tachycardia

A Step in the Right Direction?
Electrophysiologic mechanisms of ventricular tachycardias include *reentry, automaticity, and triggering*. Inducible sustained ventricular tachycardias are *monomorphic*. The figure illustrates a typical electrocardiogram (ECG) pattern of ventricular tachycardia.
Basis for the Judgment & Recommendations in this Report

A prospective study that extended from January 1990 included 242 consecutive patients in whom---and often before and after---right repair of CHD. Perloff JK, Middlekauf HR, Stevenson WG, et al. Usefulness of Post-ventriculotomy Signal Averaged Electrocardiograms in Congenital Heart Disease. Am J Cardiol 2006;98:1646–1651
Definition & Implications

A positive SAECG is defined as a filtered QRS duration $> 145$ msec plus root mean square of the terminal $40$ msec of the filtered QRS in microvolts, and/or low amplitude signal in terminal filtered QRS $> 50$ msec.

A positive SAECG indicates the presence of...
SAECG
With Late Potentials
The Trigger

A slow conduction arrhythmogenic reentrant substrate remains dormant unless activated (triggered). Accordingly, the overt expression of reentrant MVT requires a susceptible substrate and an effective trigger. Severe pulmonary regurgitation is such a trigger.
Established Risk Factors for MVT

These factors include scalar QRS duration increase in QRS duration $\geq 30$ msec over pulmonary regurgitation, depressed right function, ventricular ectopic beats induced $\geq 3$ consecutive monomorphic ventricular 
$\geq$age at ventriculotomy, and a decade or

Importantly, patients with QRS duration negative SAECG’s, and patients with QRS duration negative SAECG’s, so the ORS duration
Intracardiac Electrophysiology

When sustained MVT is inducible in SAECG’s, the commonest site of the slow substrate is along the ventriculotomy scar.
The Best Results

Substrates can be localized by mapping with radiofrequency ablation.