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Clinico-basic Convergence

Morphometry of the triangle of Koch and position of the coronary sinus opening in cadaveric fetal hearts

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ABSTRACT

Aims: The aim of the present study was to determine the variations in the position of the coronary sinus (CS) ostium in normal cadaveric fetal (28 weeks or more) hearts and to assess the impact that these variations had on the dimensions of the triangle of Koch (TK).
Methods: This cross-sectional analytical study was conducted on 28 fetal hearts. The dimensions and area of the TK were calculated by two methods, M1 (anatomical) and M2 (clinical). The position of the CS was defined with respect to the tendon of Todaro. Differences between M1 and M2 were estimated using the paired *T* test. Pearson's correlation coefficient and the adjusted correlation coefficient were used to estimate the strength of association between measurements made by the methods.
Results: Ten (35.7%) cadavers were male and 18 (64.3%) female. The mean gestational age was 32.4 ± 3.3 weeks. Using M1, the mean dimensions of the triangle in millimeters (mm) were 9.2 ± 2.2, 6.6 ± 1.8, and 6 ± 2.4 respectively for *a*, *b* and *c*. Similarly, the dimensions using M2 were 7 ± 2.1, 4.7 ± 1.5, and 4.8 ± 2.2. The area in mm^2 was 20.4 ± 10.4 and 11.7 ± 6.7 using M1 and M2 respectively. All measurements were significantly greater with M1. All correlation coefficients were high and significant. The CS ostium and tendon of Todaro maintained a relatively constant positional relationship.
Conclusions: Significantly higher values were noted in the dimensions of TK using M1. High significant positive correlations were observed in measurements made by the two methods. The CS ostium was relatively constantly placed within the TK.

What is already known?

- The dimensions of the triangle of Koch in adults and older children

What this study adds

- The dimensions of the triangle of Koch and position of the coronary sinus ostium in near-term fetuses

1. Introduction

The coronary sinus (CS) is the major vein of the heart which opens into the right atrium. The CS is one of the landmarks that is used to define the triangle of Koch (TK). The TK is situated in the inter-atrial septum of the right atrium. The septal leaflet of the tricuspid valve and the tendon of Todaro are the other anatomical landmarks that are used to define the TK. The atrio-ventricular (AV) node is located at the apex of this triangle.[1]

Accessory conducting tissue responsible for supraventricular arrhythmias may course within the boundaries of the TK. The ostium of the CS is used as a site of entry into the right atrium during catheter ablation procedures used in the treatment of resistant supraventricular arrhythmias. Variations in the dimensions of the TK are likely to impact the outcomes of these procedures, especially in children.[2] With advances in technology, ablation procedures are increasingly being performed in neonates.[3,4] In children, unlike adults the size of the TK is proportional to body size. Therefore, during ablation of a lesion of fixed size,

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there is a greater likelihood of damaging vital neighboring structures as compared to adults.[5]

While there have been a number of studies regarding the dimensions of the TK in older children, there is a paucity of data in neonates.[2,6,7] With catheter ablation procedures being increasingly carried out in neonates, it becomes imperative to have normative data in this age group. The CS ostium is one of the key landmarks in this region.[8] Though its morphometric characteristics have been reported in studies conducted in adults, the variability of its location relative to the other boundaries of the TK has not.[8–11] This calls for a better understanding of the morphometry of the TK for ensuring successful ablation. Variations in the position and size of the CS ostium are likely to have a greater impact on the dimensions of the TK, as the other two boundaries are relatively constant in position.

A previous study compared the dimensions of the TK using two methods, one anatomical and the other used by interventional cardiologists, in postmortem adult hearts.[1] Significant differences were noted in the measurements made by the two methods.[1] The aim of the present study was to determine the variations in the position of the CS ostium in cadaveric fetal (28 weeks or more) hearts and to assess the impact that these variations had on the dimensions of the TK. The objectives of the study were to estimate the following: (1) position of the CS ostium with respect to the tendon of Todaro; (2) difference in the dimensions of the TK by two different methods (M1 and M2); (3) strength of association between the dimensions of the TK using M1 and M2; (4) strength of association between the dimensions of the TK using M1 and M2 after adjusting for the position of the CS.

2. Materials and methods

2.1. Study design and sampling

This was a cross-sectional, analytical study conducted at the Department of Anatomy in a medical college attached to a tertiary care hospital in South India. Ethical clearance was obtained from the Institutional Ethics Committee before commencement of the study. Cadavers of fetuses already available in the department with a gestational age (estimated using crown-rump length) more than or equal to 28 weeks were included.[12] Fetuses with cardiovascular anomalies were excluded. Data available from an earlier pilot study in 16 fetal cadaveric hearts were used to calculate the sample size. The sample size was calculated for hypothesis testing for a difference between paired means. A final sample size of 28 was arrived at assuming a difference of 8 mm^2 in the area measurements between M1 and M2, a standard deviation of 12 mm^2 for each method, with the α error set at 5% and power at 90%.

2.2. Dissection technique and measurements

The fetal hearts were dissected out from the cadavers and separated of all their vascular connections. The right atrium was opened along the sulcus terminalis. The TK was defined and photographed from above in a standardized manner, along with a scale for calibration and a pointer in the CS opening. All measurements were subsequently made on the photographs so obtained.

The methods M1 and M2 used to estimate the sides and area of the TK are shown in Fig. 1.[1] For measurements by M1, line *a*1 was the tendon of Todaro. Line *b*1 was drawn through the CS opening, joining the tendon of Todaro and septal leaflet of the tricuspid valve line *c*1 was drawn along the septal leaflet of the tricuspid valve extending from the central fibrous body to the line *b*1 (Fig. 1a).[1] Using M2, line *a*2 was the tendon of the Todaro. Line *b*2 was formed by joining the nearest point on the CS opening toward the side of the tendon, to the septal leaflet of the tricuspid valve. Line *c*2 was drawn from the central fibrous body along the septal leaflet of the tricuspid valve to join line *b*2 (Fig. 1b).[1] When the tendon of Todaro was not prominent, traction was applied to the valve of the inferior vena cava and the linear prominence so formed was taken to be the tendon of Todaro. The length of the sides of the TK and its area by M1 and M2 were then estimated using ImageJ, an open source image analysis software.

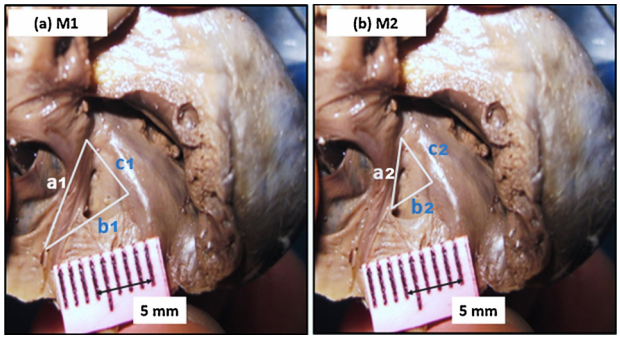

Fig. 1. A superior view photograph of the TK, after opening the anterior wall of the right atrium with a scale for calibration. The sides of the TK using M1 (a) and M2 (b) are marked. *a*1, *b*1, *c*1 – sides of the TK using method 1; *a*2, *b*2, *c*2 – sides of the TK using method 2; M1 – method 1; M2 – method 2.

The position of the CS with respect to the central fibrous body and the tendon of Todaro was estimated as shown in Fig. 2. A line *K* was drawn from the central fibrous body to the nearest margin of the CS opening. The angle subtended by line *K* with side *a* (angle *k*) was measured. A perpendicular (*p*) line was drawn from the CS end of line *K* to side *a*, and the length of this line was measured. The magnitude of angle *k* and the length of *p* were used to define the position of the CS ostium.

2.3. Statistical analysis

The paired *T* test was used to estimate any differences in the measurements between M1 and M2. The strength of association

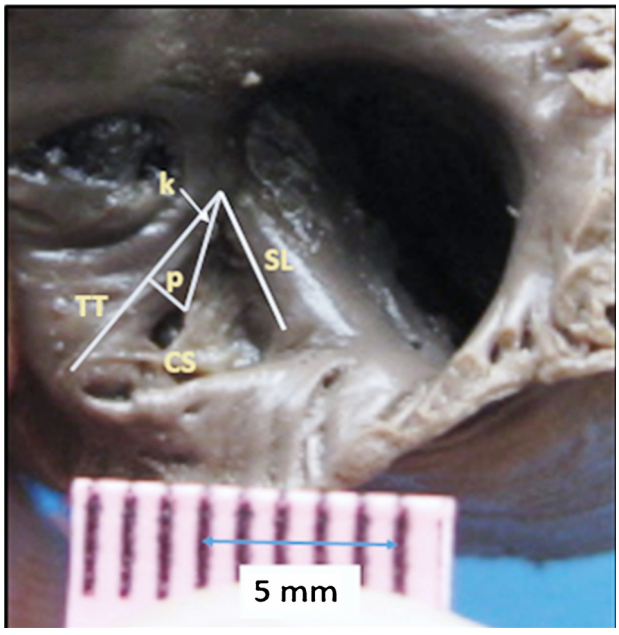

Fig. 2. A superior view photograph of the TK showing the method used to define the position of the CS ostium in relation to the tendon of Todaro. CF – central fibrous body; CS – coronary sinus ostium; SL – septal leaflet of the tricuspid valve; TT – tendon of Todaro; *K* – line joining the nearest margin of the CS ostium and the central fibrous body; *k* – angle subtended by *K* with side *a*; *p* – perpendicular drawn from *K* to side *a*.