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Notes on the morphology of the tricuspid valve in the adult human heart

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Rapid progress in the field of interventional cardiology has caused research in the field of morphometry of the heart to be in constant demand [7–10, 12]. In this study, performed on a group of 75 adult human hearts, the authors have attempted to assess the form and number of the main and accessory cusps in the tricuspid valve. We have classified particular forms into 8 groups, depending on the number of cusps and we have divided the cusps into 3 main groups, depending on the support of the chordae tendineae.

Key words: tricuspid valve, human heart, right ventricle, cusp, commissure, morphology

INTRODUCTION

Despite intense interest in cardio-anatomy, there are many issues to be examined with great care. The problem of the morphology of the atrioventricular ostia is still an open question. The tricuspid valve, which, in the light of existing research, is a heterogeneous structure with great variability in its structure, has remained unexamined. However, there is some research which describes the structure of the tricuspid valve, although authors differ in their attitudes toward this. The number of cusps, their configuration and their size are still controversial. One of the first who paid attention to the presence of accessory cusps was Tandler in 1913 [16]. Accessory cusps were also described by Testut and Latarjet in 1923 [17] and Jastrzębski in 1926 [5], but their descriptions are based on a limited number of cases. Descriptions of the chordae tendineae and the localisation of the papillary muscles differ from one study to another. The dynamic progress of therapeutic and diagnostic cardio-invasive procedures implies a marked rise in interest in studies of cardiac anatomy and it is reasonable, therefore, to resume research on the tricuspid valve.

MATERIAL AND METHODS

The study material consisted of 75 formalin-fixed adult human hearts, between 27 and 79 years of age and of both sexes, in which no macroscopic developmental failures and pathological changes had been found. The hearts were opened by dissection of the wall of the right atrium between the ostia of both venae cavae and then along the right margin of the right ventricle. The walls of the right part of the heart were drawn aside to reveal the valvular apparatus. We estimated the number of cusps, their localisation, morphology; their width and height were measured.

RESULTS

Using as the criterion for division the number of cusps of the tricuspid valve, we established 5 types (Table 1). The most common was a 4-cuspidal structure consisting of 3 main cusps and one accessory cusp (CAc). This form appeared in 40% of cases in the group of hearts studied (Fig. 1). On the basis of analysis of the localisation of the accessory cusps we established 3 subtypes: 1) the accessory cusp localised between the posterior cusp (CP) and the sep-

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Table 1. Frequency of particular types and subtypes of tricuspid valve

Type	Number of cusps	Occurrence in studied group [%]
1	3	9.3
2	4	36.15
Subtype A		23.8
Subtype B		7.8
Subtype C		4.5
3	5	33.3
4	6	13.3
5	7	4.1
Subtype A		2.6
Subtype B		1.3

CA — anterior cusp, CP — posterior cusp, CS — septal cusp, subtype A — the accessory cusp localised between CP and CS, subtype B — the accessory cusp localised between CA and CS, subtype C — the accessory cusp localised between CA and CP

tal cusp (CS) — this configuration was the most frequent subtype of the 4-cuspidal structure (25.3%); 2) the accessory cusp localised between the anterior cusp (CA) and the CS — this subtype was rare and appeared in 9.3%, and 3) the accessory cusp localised between CA and CP, which occurred in 5.3% of cases.

An unusual form of the tricuspid valve was a 5-cuspidal form with 2 accessory cusps localised between CA and CS and between CS and CP. This variant appeared in 33.3% of the hearts analysed (Fig. 2).

Another unusual type observed by us consisted of 6 cusps — 3 main cusps and 3 accessories. This appeared in 13.3% of the hearts analysed (Fig. 3).

In only a small percentage (9.3%) of the hearts studied did we observe the "typical" form of the tricuspid valve without accessory cusps (Fig. 4).

Our analysis yielded an assessment of the rarest configuration of all , a 7-cuspidal form of the tricuspid valve. This appeared in only 4% of the hearts studied. In this type the accessory cusps appeared in the following configuration: 2 between CS and CP, one between CS and CA and the last one between CA and CP (Fig. 5).

We classified the accessory cusps into 2 groups according to Grzybiak's categories for the mitral valve [2–4] and those of Szostakiewicz-Sawicka [14] and Szostakiewicz-Sawicka and Grzybiak [15]. The more frequent were spurious cusps (supported by chordae tendineae arising from one apex of the papillary muscle — 58.6% of the hearts studied) (Fig. 6) and the less frequent group consisted of real accessory cusps (supported by chordae tendineae arising from 2 apices of papillary muscle — 41.3% of the hearts studied) (Fig. 7).

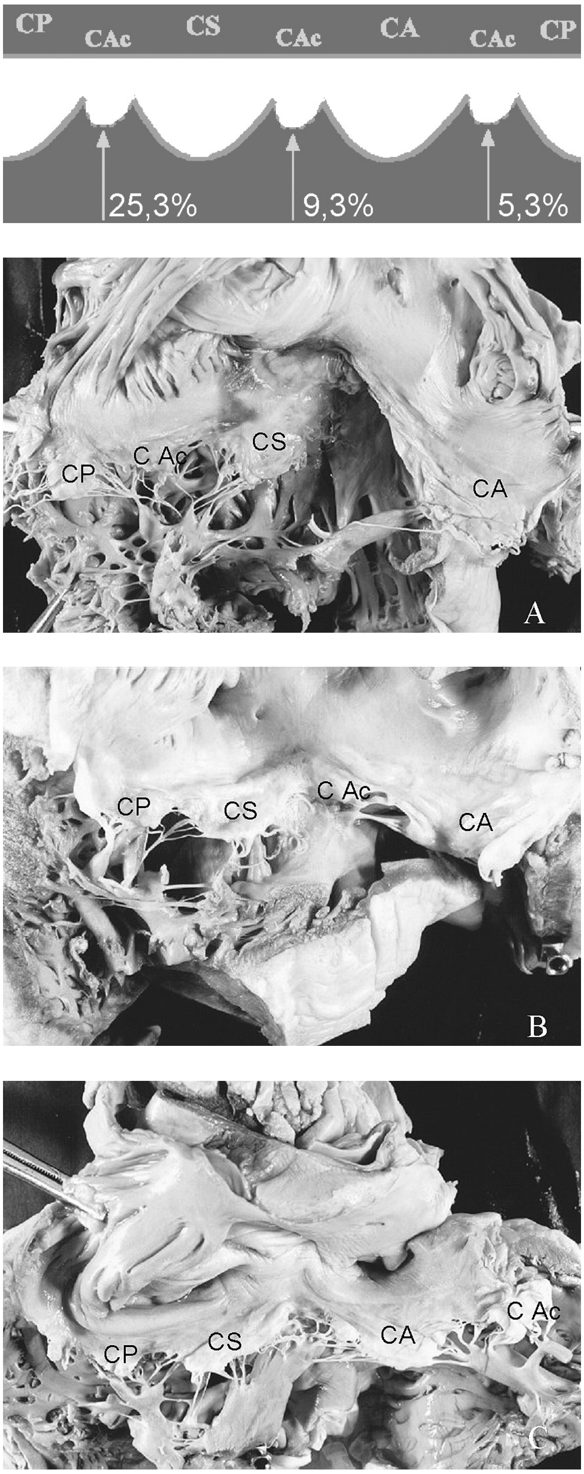

Figure 1. Subtypes of four-cuspidal form of tricuspid valve. **A**. CAc is localised beetween CS and CP; **B.** CAc beetween CA and CS; **C.** CAc beetween CA and CP. CAc — accessory cusp, CS — septal cusp, CP — posterior cusp, CA — anterior cusp.

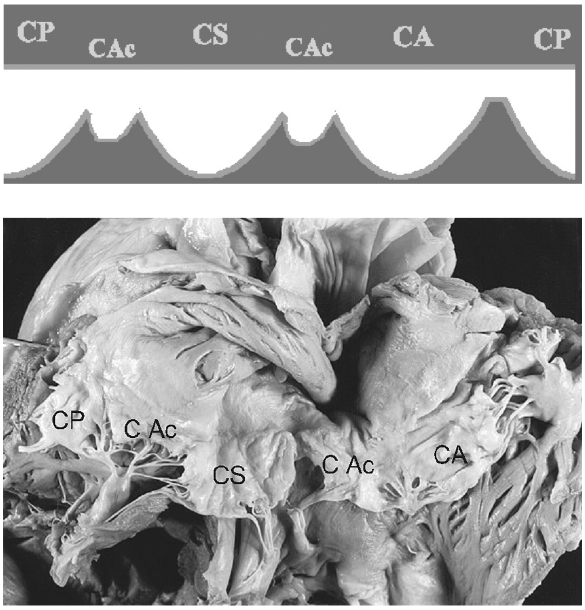

Figure 2. Five-cuspidal form of tricuspid valve. Abbreviations as in Figure 1.

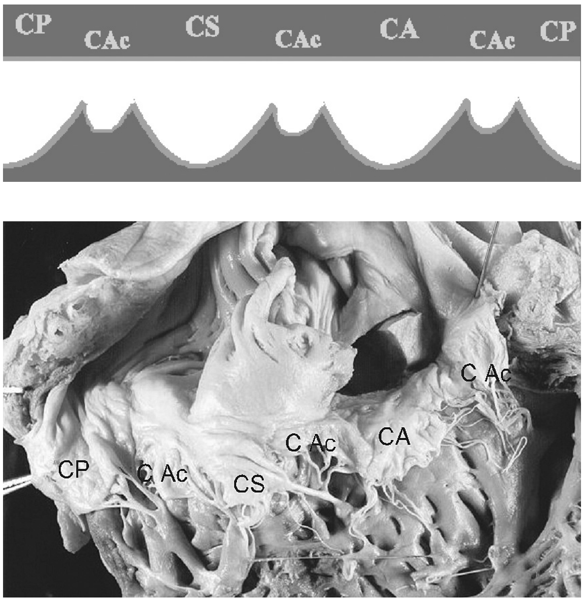

Figure 3. Six-cuspidal form of tricuspid valve. Abbreviations as in Figure 1.

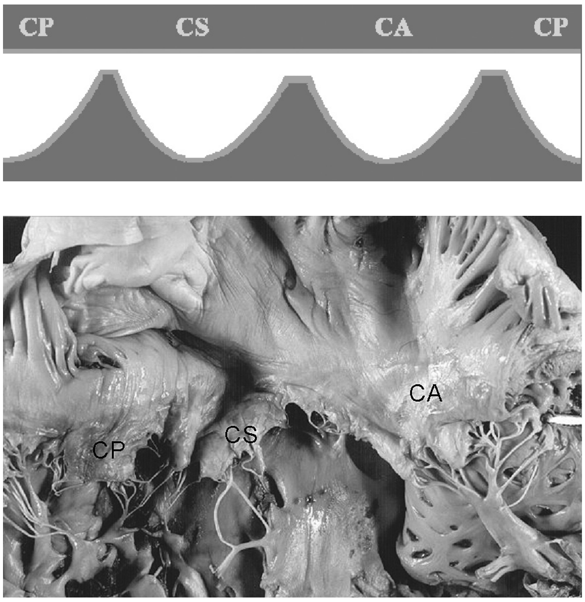

Figure 4. "Typical" tricuspid form of tricuspid valve. Abbreviations as in Figure 1.

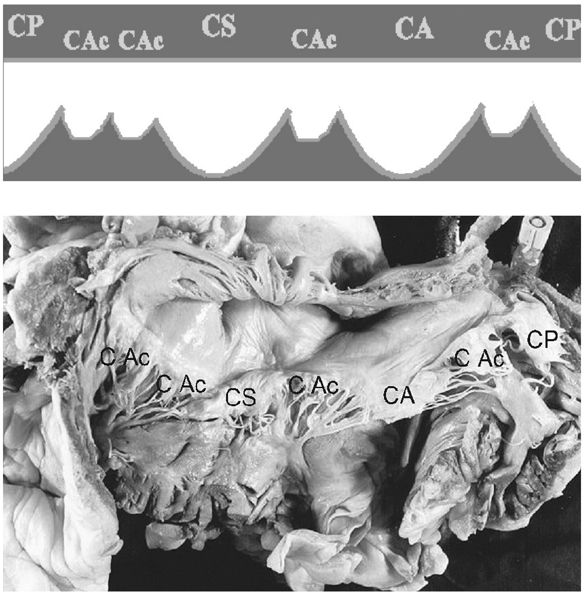

Figure 5. Seven-cuspidal form of tricuspid valve. Abbreviations as in Figure 1.

The shape analysis of the cusps of the tricuspid valve showed that all were triangular. Analysis of their morphology, in particular, showed little differentiation. However, the CS usually resembled a triangle with its base longer than its height, while for the CP the relationship between the base and height of the triangle was inverted. We noted that this relationship was variable in CA and accessory cusps.

The height of cusp was defined, according to Szostakiewicz-Sawicka [14], Szostakiewicz-Sawicka and Grzybiak [15] and Grzybiak [2–4], as the distance between the base and the apex of the cusp. This dimension was termed the width of the cusp by Łukaszewska-Otto [11], but we used the terminology of Grzybiak and Szostakiewicz-Sawicka, as this corresponds to the convenient terms for trian-

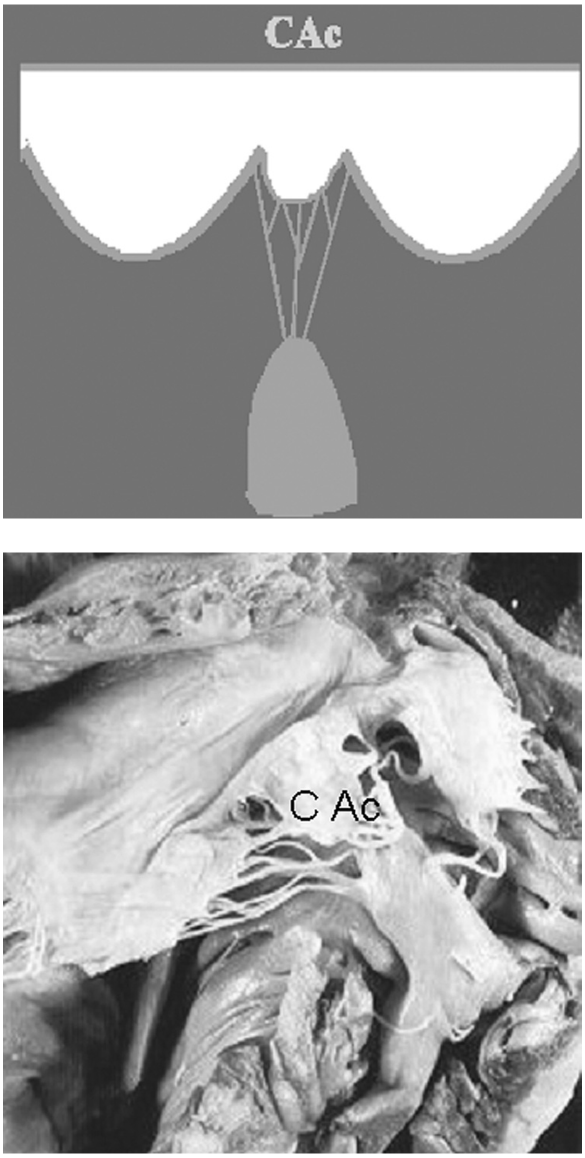

Figure 6. Spourious CAc. Abbreviations as in Figure 1.

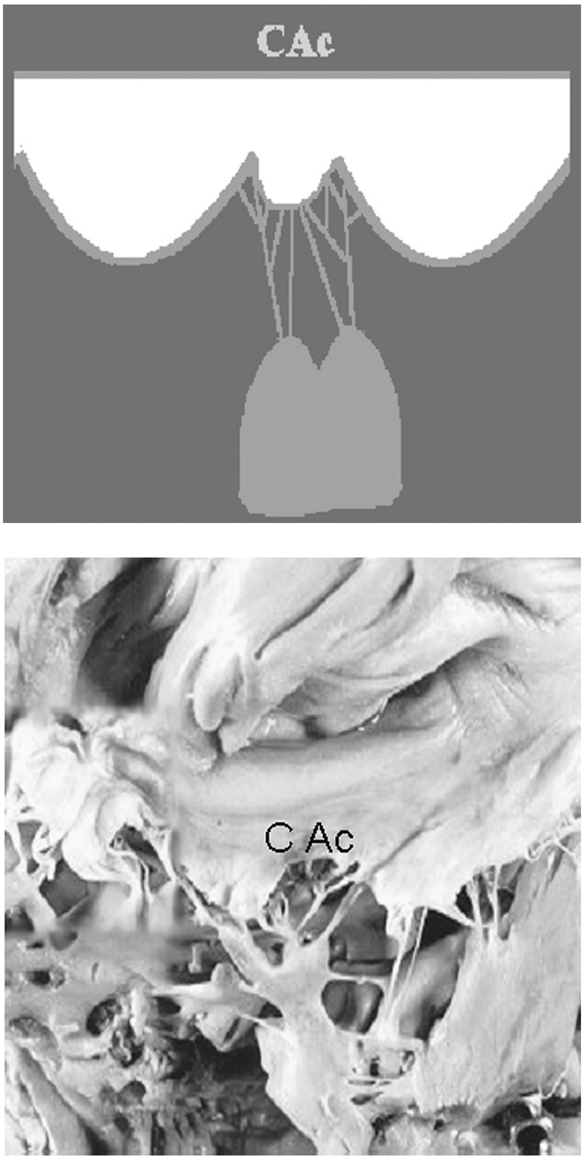

Figure 7. Real CAc. Abbreviations as in Figure 1.

gles, to which the cusps of the valve are compared, while Łukaszewska's terminology would throw this into confusion. The measurement analysis of several cusps led us to arrive at the conclusion that the height of CA is greater than that of the others. CP was usually lower than CA, but the lowest was CS. Accessory cusps were always lower than the main ones (Table 2).

The mean height of CA was 23.88 ± 0.85 mm, the mean height of CP was 21.35 ± 0.90 mm, the height of CS — 18.33 ± 0.98 mm and the mean height of the accessory cusps 14.88 ± 0.99 mm. During analysis of the accessory cusps we observed that the highest was localised between CA and CP, that between CS and CP was lower and the lowest was between CA and CS. We observed sex-associated differences in the size of the accessory cusps. Cusps in male hearts were significantly higher than in female hearts (21.92 ± 0.92 mm in male hearts vs. 19.61 ± 0.88 mm in female ones). This problem requires further investigation.

Table 2. Height of particular cusps of the tricuspid valve

Cusp	Mean height [mm]	SD
Anterior cusp	23.88	0.85
Posterior cusp	21.35	0.90
Septal cusp	18.33	0.98
Accessory cusp	14.88	0.99

We evaluated the commissure localised between the cusps. We defined commissure as that part of valve contained between the annulus fibrosus and the peak of the intercuspidal incision. We observed commissure in a majority of the hearts examined. The length of the commissure was 7.11 ± 0.97 mm) and no significant difference was observed in the size of particular commissure. This problem will form the subject of another study.

DISCUSSION

The results of our study show great variability of the right atrioventricular valve. Only in a small percentage of the hearts examined was the valve normally termed the "tricuspid" composed of 3 cusps and instead with multi - cuspidal forms prevailed.

This relation was also studied by Szostakiewicz-Sawicka [14], Łukaszewska-Otto [11] and Kosiński et al. [6]. Szostakiewicz-Sawicka performed her studies on a group of 30 human hearts. The 3-cuspidal form appeared in 30%, the 4-cuspidal form in 46.6% and the 5-cuspidal form in 23.3%. In a study of Łukaszewska-Otto [11] performed on a group of 130 human hearts the 3-cuspidal form appeared in 8.46% and the 4-cuspidal form in 36.15%. The accessory cusp was localised between CP and CS in 23.8%, between CA and CS in 7.8% and between CA and CP in 4.5%. The 5-cuspidal form appeared in 33.85%, the 6-cuspidal form appeared in 17.69% and both the 7 and 8-cuspidal forms appeared in 1.53%. The results of Kosiński et al. [6] were as follows: the 3-cuspidal form appeared in 9.1%, the 4-cuspidal form appeared in 38.2%, the 5-cuspidal form in 32.7%, the 6-cuspidal in 16.7%, and the 7-cuspidal in 3.6% of cases.

It is notable that Szostakiewicz-Sawicka and Grzybiak [15] compared the structure of the cusps of the right atrioventricular valve in 84 hearts of other primates and the author ascertained the dependence of the form of the valve on phylogenetic evolution.

The divergence of our results with those presented above may be due to the fact that Szostakiewicz--Sawicka used human hearts as a comparative group with 84 monkey hearts.

Our results are convergent within the 3 to 7-cuspidal form range with the results of Łukaszewska-Otto [11] and Kosiński et al. [6]. We did not observe an 8-cuspidal form, which can be explained by its rare occurrence.

The authors of the research presented above did not compare the shape and size of the accessory cusps.

Commissure of the tricuspid valve were described by Rocache [13] and commissure of the mitral valve by Grzybiak [2]. Our criteria for the assessment of commissure are compatible with both these studies. Grzybiak increased understanding of commissure, as did Rocache, and coined the term "commissural zone". The term "commissure" does not exist in *Nomina Anatomica* [18] but has been introduced into practice by clinicians [1].

It is a well known fact that endocarditis causes fusing of the valvular cusps, implying enlargement of the distance between the annulus fibrosus and the intercuspidal incision. There is little data on this and what does exist is fragmentary. It seems reasonable to calculate the height of the commissure in normal hearts in order to assess the criteria for distinguishing the normal and the pathological — valvular stenosis.

It would also be reasonable to qualify the relationship between the height and width of the commissure and their number.

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