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CASE REPORT

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Dual left anterior descending coronary artery (type III) and the presence of myocardial bridges: a post-mortem examination

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An observational examination of the heart was performed in the Department of Anatomy, during the routine autopsy of an 89-year-old man. The heart was fixed in 10% formalin and an analysis of arterial vasculature was performed (used morphometric abbreviations below [mm]: L — length; D — diameter of origin). Trifurcation of the left main coronary artery (L = 17.4; D = 8.1) was observed during the study, which originated in the left aortic sinus and was followed by three branches: proper left anterior descending artery (pLAD; L = 11.2; D = 7.4), intermediate branch (L = 98.6; D = 3.5) and left circumflex artery (L = 104.2; D = 4.9), respectively. In the pLAD division, there was noted LAD1 (long) which was running in the interventricular septum (L = 32.2) and further in the subepicardial segment (L = 109.3) in the anterior interventricular groove towards the apex (AC) (LAD1; L = 141.4; D = 6.3) and LAD2 (short) running subepicardial in the anterior interventricular groove in the AC direction (LAD2; L = 68.4; D = 3.2). Four diagonal branches (DB) and 9 septal perforators (SP) were observed in the course of LAD1; regarding the LAD2 there were 6 SP only. It is worth noting that the first SP supplying the interventricular septum came from LAD2. Another interesting aspect of the observation was the occurrence of 4 myocardial bridges on the LAD1, LAD2, DB1 arteries and on the second obtuse marginal branch (OM2), respectively.
This case describes a rare anatomical anomaly of the LAD course and reminds clinicians of the need for careful planning of cardiac surgeries and percutaneous interventions on the coronary arteries. (Folia Morphol 2020; 79, 3: 634–639)

Key words: left coronary artery, dual left anterior descending coronary artery (type III), anatomical variation, morphometry, myocardial bridges

INTRODUCTION

Anatomical variants of the coronary arteries are usually detected as ancillary findings during imaging or autopsy [26]. General variability in the coronary system of the heart, related to its various vessels, is characterised by a low incidence in the range of 0.13–1.3% [5, 28, 33]. Agarwal and Kazerooni [1] using computed tomography examinations showed

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the incidence of variability in the dual left anterior descending artery (LAD) at the level of 0.29% (2/670). Bozlar et al. [6] recorded the incidence (dual LAD) at the level of 4% (56/1337), including LAD type III at the level of 0.22% (3/1337). In another study, Nikolić et al. [23] performed a coronary artery analysis on hearts collected from human cadavers in order to assess the protective role of myocardial bridges (MB) in the development of atherosclerotic lesions in the coronary parts below the bridge, and showed the frequency of LAD type III to be 0.28% (10/3500), which concerned only men. It can therefore be assumed that dual LAD is one of the rarest coronary anomalies [6]. According to some literature data, coronary artery anomalies are among the most common cardiovascular causes in the case of sudden death in young patients [11]. It is worth noting that the clinical impact of variability within angioarchitectonics of coronary arteries depends on the ability of "atypical" arteries to supply the relevant areas of the heart with blood [30].

CASE REPORT

A cardiac observational study was carried out at the Department of Anatomy, during a routine autopsy for teaching purposes as part of a conscious body donation programme. The heart, collected from the cadaver of an 89-year-old man, underwent preservation in 10% formalin, followed by the analysis of arterial vascularisation. To measure the length of the vessels, a digital calliper was used, equipped with an LCD display (Mitutoyo, Japan, accuracy up to 0.02 mm). Straight sections of the arteries were measured by placing the fixed jaw of the calliper at the beginning of the vessel section and the sliding jaw at its end. In the case of curvilinear arteries, the measurement was performed indirectly using silky, non-absorbable suture thread (Péters Surgical), in which the thread was first placed along the course of the artery to establish the length and then measured with the calliper to obtain the length. Using the same calliper, the external diameters of the arteries at the initial points of branching of these vessels were also measured as well as the depth level in the myocardium.

The coronary artery observations were that left main coronary artery (LMCA) trifurcation was observed, its origin was the left aortic bay (LSV), and its subsequent course ended with the emergence of three branches, respectively: the proper left anterior descending artery (pLAD), the intermediate branch (IMB) and the left circumflex artery (LCxA) (Fig. 1A). The LMCA length was 17.4 mm, while its diameter at the point of branching from the aorta was 8.1 mm. In the right direction, from the LMCA trifurcation, a pLAD was created (the diameter at the point of its origin was 7.4 mm) (Fig. 1B), whose course at a distance of 11.2 mm from the trifurcation point was divided into two vessels:

— LAD1 (long); over a distance of 32.2 mm it runs intramuscularly in the interventricular septum and further subepicardially in the anterior interventricular sulcus (109.3 mm) toward the apex cordis (AC) — total length of 141.4 mm, diameter at the division point of the pLAD was 6.3 mm;
— LAD2 (short); it runs over a distance of 18.3 mm intramuscularly in the interventricular septum, and further subepicardially in the anterior interventricular sulcus towards the AC — total length of 68.4 mm, diameter at the division point from the pLAD was 3.2 mm.

Over the course of LAD1, 4 diagonal branches (DBs) responsible for the vascularisation of the anterior wall of the left ventricle and 9 septal perforators (SP) were observed, whereas in the case of LAD2 there were 6 SPs (Fig. 1B); in total, the vascularisation of the anterior part of interventricular septum corresponded to 15 SPs from LAD1 and LAD2. It is also worth noting that the first SP vascularising the interventricular septum was from LAD2. From the Figures 1A and 1B, it can be concluded that DB1, DB2, LAD1, and LAD2 are originated from the pLAD trunk together; however, a thorough analysis of this case from every perspective allows to state that DB1 and DB2 are vessels derived from LAD1.

From the LMCA, an LCxA with a diameter of 4.9 mm arises. It ran to the left, towards the coronary groove, while its length was 104.2 mm. Regarding the distance from the trifurcation point (PT), the following branches were observed in the course of LCxA: atrial branch (AB) at a distance of 6.2 mm, the first artery of the obtuse margin (OM1) at a distance of 26.4 mm and the second artery of the obtuse margin (OM2) at a distance of 31.7 mm (Fig. 1A). The terminal section of the LCxA was the posterolateral branch (PL) terminating at the lower surface of the left ventricle (Fig. 2B).

An additional IMB between pLAD and LCxA extending in the anterolateral direction was observed. At the PT, the diameter of this artery was 3.5 mm, over a distance of 27.2 mm it ran subepicardially, while further over a distance of 71.4 mm the artery

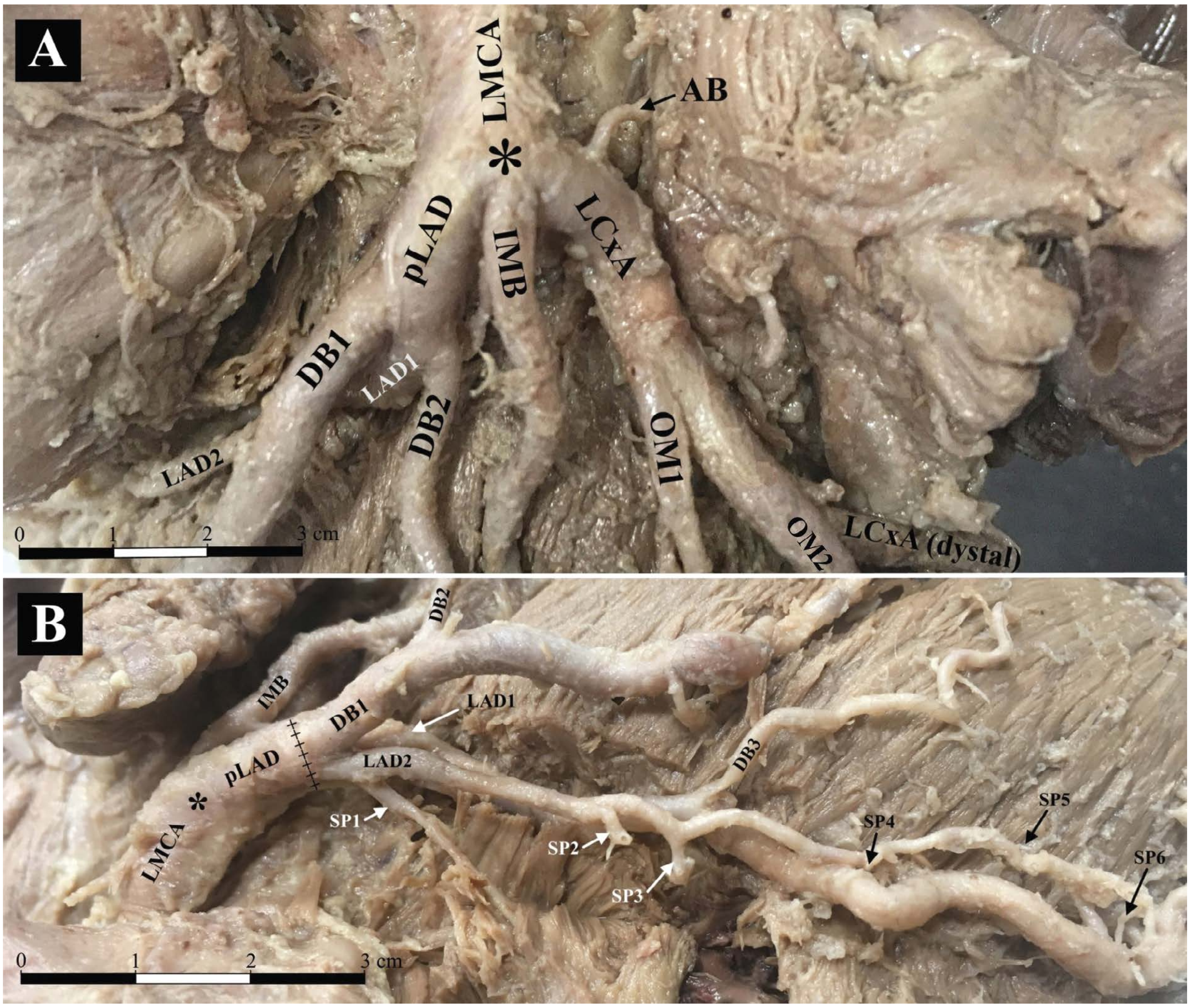

Figure 1. A. Trifurcation of left coronary artery; **B.** Origin and course of left anterior descending artery (short) and presence six septal perforators; LMCA — left main coronary artery; pLAD — proper left anterior descending; IMB — intermediate branch; LCxA — left circumflex artery; LAD1 — left anterior descending (long); LAD2 — left anterior descending (short); DB1–3 — diagonal branch first, second and third; OM1–2 — obtuse marginal branches (first and second); SP1–6 — septal perforators (from one to six); AB — atrial branch; *trifurcation point; ++++ pLAD dividing line.

ran intramuscularly; the total length of this artery was 98.6 mm (Fig. 1B). Another interesting aspect of the observation was the occurrence of 4 MB on the LAD1, LAD2, DB1 and OM2 arteries, respectively (Fig. 2A, B). Table 1 shows the length of the MB, the distance from the artery origin to the MB, the depth of the MB, i.e. the thickness of the muscle tissue band that ran over the coronary artery and the diameters before and after the myocardial bridge.

DISCUSSION

In terms of anatomy, the LAD arises from the LMCA, runs in the anterior interventricular sulcus (AIS) towards the apex cordis and gives diagonal and septal branches that penetrate the interventricular septum, while the diagonal branches extend to the anterior wall of the left ventricle, and sometimes to the anterior wall of the right ventricle (diagonal right ventricle) [1]. The occasional dual LAD (in the range of 0.13–4% [6, 28] is characterised by the presence of two distinct vessels in the AIS and usually results in a short LAD ending in the proximal part of the AIS and a long LAD artery that proximally extends beyond the AIS, but ends in the distal part of the AIS. Coronary artery anomalies, including dual LAD, are very interesting both scientifically and clinically. In 1983, Spindola-Franco et al. [29] proposed a classification and divided them into four types. In types I–III, the LMCA gives rise to a common

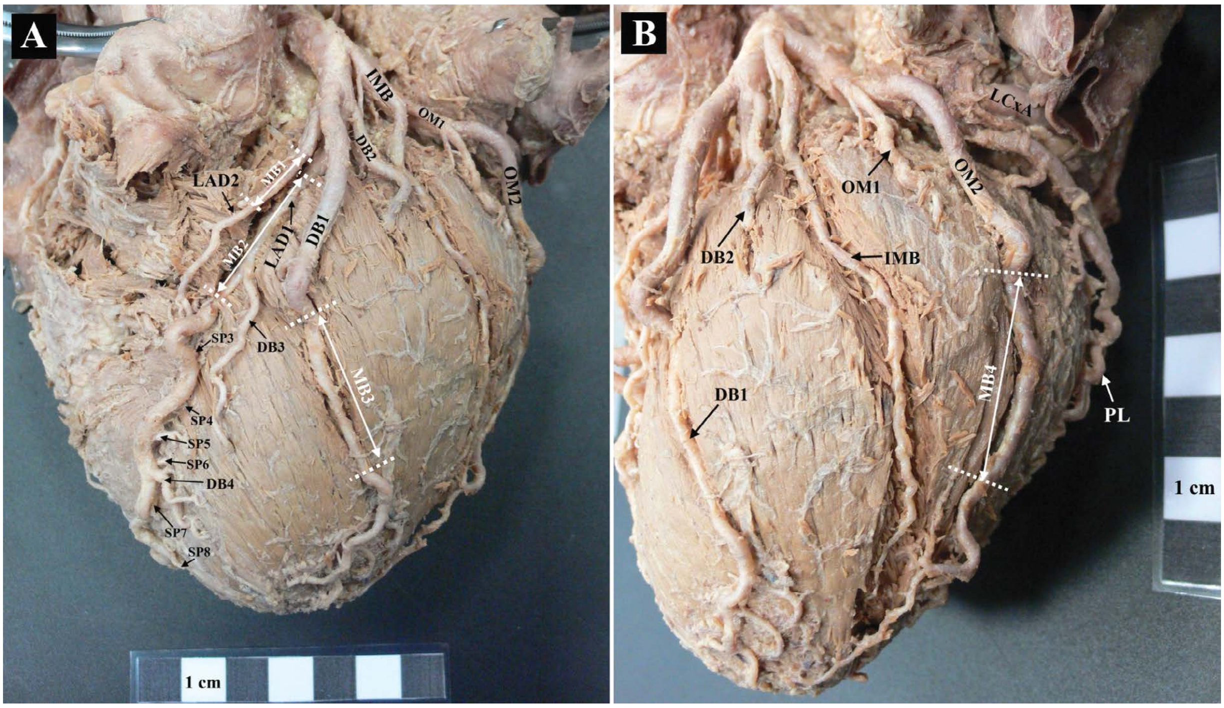

Figure 2. A. View of the anterior wall of the left heart ventricle (dissected); **B.** View of the anterolateral wall of the left heart ventricle (dissected); IMB — intermediate branch; LCxA — left circumflex artery; LAD1 — the first left anterior descending (long); LAD2 — the second left anterior descending (short); DB1–3 — diagonal branch first, second and third; OM1–2 — obtuse marginal branches (first and second); SP3–8 — septal perforators (from the third to the eighth); MB1–4 — myocardial bridges (from one to four); PL — posterolateral branch.

Table 1. Measurements [mm] of myocardial bridges (MB) and diameters of their underlies arteries

Coronary artery branch	Length of MB	Thickness of MB	Distance from the origin	Pre-bridge diameter (D1)	Post-bridge diameter (D2)
LAD1	32.2	8.1	13.3	6.2	5.9
LAD2	18.3	4.4	8.2	3.1	2.9
DB1	38.3	3.1	58.9	3.4	3.0
OM2	42.3	1.9	44.6	3.3	2.8

LAD1 — left anterior descending (long); LAD2 — left anterior descending (short); DB1 — diagonal branch first; OM2 — obtuse marginal branches

(proper) LAD, which is then divided into a short and long LAD. In types I–III, the end of the short LAD is in the proximal part of the AIS, whereas the end of the long LAD is in the distal part of the AIS. The differences between types I–III relate to the course of the proximal part of the long LAD: in type I — a subepicardial course on the left side of the proximal part of AIS, type II — a subepicardial course on the right side of the proximal part of AIS, type III — an intramuscular course in the interventricular septum. In type IV, the short LAD arises from the LMCA and its end is in the proximal part of the AIS, while the long LAD arises from the proximal part of the right coronary artery and proximally it runs subepicardially in the front of the right ventricular outflow tract and terminates in the distal part of the AIS.

Taking this division into account, the described case of the dual LAD should be classified as type III. In recent years, six types of dual LAD have been reported [17, 18]. In the latest studies, Boznar et al. [6] distinguished 9 types of dual LAD, Celik et al. [8] showed a tenth type of dual LAD, while Al-Umairi et al. [3] noted an eleventh type of dual LAD. It is worth noting that most of the new studies on dual LAD are based on imaging studies.

Despite the changes in the classification, where 4 types were initially distinguished, and currently 11 types are given, some dual LAD types show a very low frequency of occurrence, as in the case of the type III dual LAD. According to the original classification proposed by Spindola-Franco et al. [29], this type is characterised by a proximal intramuscular course of the long LAD.

In the literature, there are few studies on the morphometric aspects of the type III dual LAD based on post-mortem studies. Nikolić et al. [23], analysing the vascularisation of 3500 hearts over 12 years of research, showed ten cases of type III dual LAD. The vast majority of studies on this type of dual LAD come from morphological case studies, while the original works are based on radiological studies. The average LMCA lengths in the literature show high variability [14, 16, 25]. Miklaszewska et al. [20] give an average LMCA length of 17 mm, whereas for LAD — an average length of 137.6 mm. Usually in the larger hearts there is a longer left coronary artery [13, 14].

The MB in the heart are muscle tissue bands running over the coronary arteries, which during the contraction of the cardiac muscle exert pressure on the blood vessel and thus affect the narrowing of its lumen and, consequently, the impairment of its blood flow. Already in the eighteenth century, this type of anomaly was described, but it was only in the 1960s that more attention was paid to the occurrence of MB and their clinical significance [27].

The range of the incidence of MB is wide and related to research methodology. As it results from the literature data, in the imaging studies the presence of MB in the range of 0.5–16% of the cases studied [4, 15, 24] is observed, whereas in the autopsy studies there is a much more frequent occurrence of MB, in the range of 15–86% [7, 12, 21]. The presence of MB can be observed in relation to any coronary artery; however, the majority — 70% to 98% — concern LAD [9, 31]. Nasr [22], in his studies on hearts from 60 human cadavers, showed the presence of MB in 27 (45%) hearts, mainly in the central segment of the anterior interventricular artery (52.8%) and to a lesser extent in its diagonal branch (13.8%), the posterior interventricular artery (13.8%), and the middle and left marginal branch (5.6%). In the study cited, the average length of MBs was 24.9 ± 1.98 mm, and their thickness was 2.28 ± 0.13 mm, while the average distance from the artery origin to the MB in male hearts was 44.5 ± 2.5 mm; in the case of vascular diameters before and after the MB, Nasr [22] noted (in male hearts) the mean variability for LAD (3.2 ± ± 0.28 mm vs. 3.02 ± 0.12 mm) and DB (2.54 ± ± 0.16 mm vs. 2.42 ± 0.14 mm). Nikolić et al. [23], when examining MB occurring in type III dual LAD, recorded their length in the range of 7–35 mm, and a thickness in the range of 3–6 mm. In this case, they were quite long bridges, from 18.26 mm on LAD1 to 42.25 mm on OM2; their thickness was in the range of 1.89 mm on OM2 to 8.09 mm on LAD1. According to the literature data, the clinical significance of MB is not clearly specified, there are studies in which patients with MB may function asymptomatically, but may also have coronary spasms, thrombosis and coronary dissection potentially associated with the presence of MB [10, 19, 31, 32]. Some authors indicate that due to the fact that the majority of coronary flow takes place in the end-diastolic phase, the presence of MB does not significantly impede blood supply to the myocardium [2]. This case cannot be used to discuss this issue, because there is no clinical data regarding the examined person.

CONCLUSIONS

The mere occurrence of a dual LAD usually does not manifest clinically, but the diagnosis of this rare anomaly is important, because it may be misleading during clinical diagnosis as well as of postoperative complications. This case describes the rare anatomical variability in the course of the LAD, which is a valuable source of information for clinicians, especially in surgical planning and cardiosurgical intervention.

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