

Hozumi Fukuda · Mitsutaka Ashida · Rei Ishii
Shoko Abe · Kenji Ibukuro

Anatomical variants of the lateral femoral circumflex artery: an angiographic study

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Abstract The descending branch of the lateral femoral circumflex artery (LFCA) has found recent use as a new arterial graft for coronary artery bypass grafting (CABG). Anatomical variants of the LFCA were assessed on femoral arteriograms obtained before CABG in 131 adult patients. The most common pattern, found in 78.6% of extremities, consisted of the LFCA arising from the deep femoral artery, and the arterial graft was selected from this pattern in 92.3% of patients in whom the descending branch of the LFCA was used for CABG.

Keywords Anatomy · Regional · Femoral artery · Lateral femoral circumflex artery · Angiography · Digital subtraction · Coronary artery bypass

Introduction

The lateral femoral circumflex artery (LFCA) commonly originates from the deep femoral artery (DFA), and the descending branch of the LFCA has recently been recognized as a new arterial graft for use in coronary artery bypass grafting (CABG) [5, 17]. Because of anatomical variants of the LFCA and individual differences in development of the descending branch of the LFCA, it is necessary to perform bilateral femoral arteriography before surgery for patients in whom use of the LFCA might be justified as an arterial graft [6]. In this study, we review the anatomical variants of the LFCA on angiograms obtained before CABG. Although anatomical variants of the DFA on lower limb angiograms have been reviewed by Massoud et al. [12] and Basar et al. [3],

there is no other radiological literature in which anatomical variants of the LFCA have been investigated in relation to preoperative arteriographic evaluation for CABG.

Materials and methods

From November 1998 to December 2003, we performed preoperative digital subtraction femoral arteriography in 132 patients to assess the appropriateness of the LFCA as an arterial graft for CABG. Femoral angiography was only performed on patients from whom it was possible to acquire an arterial graft from the LFCA, such as those with multivessel disease, and was not performed for patients with suspected arteriosclerosis obliterans of the lower extremities, because the LFCA is indispensable as a contributor to the collateral circulation. Of the 132 patients upon whom femoral angiography was performed, 1 was subsequently excluded because complete occlusion of the right femoral artery (FA) became apparent. Therefore, femoral arteriograms were reviewed for 262 extremities in 131 patients, 121 males and 10 females, 32–78 years old (mean, 60.2 years old). A total of 10–15 ml of 370 mgI/ml iopamidol (Iopamiron 370, Nihon Shering, Osaka, Japan) was administered into the ipsilateral external iliac artery at a rate of 2–3 ml/s, and bilateral femoral arteriograms were then obtained separately for each side, acquiring data at three frames/s using an Advantx LCA (General Electric Medical Systems, Milwaukee, WI). The images were stored in hard copy and also on videotape. All of the femoral arteriograms were reviewed by one experienced radiologist (H.F.) in order to analyze anatomical variants of the LFCA. The angiograms were evaluated using the hard copy images, and additionally from videotape when the origin of the LFCA was obscure because of superimposition of the FA and the DFA (Fig. 1). We classified the patterns of anatomical variation of the LFCA into six types according to the origin of the LFCA, as shown in Fig. 2. The anatomical variation of

H. Fukuda (✉) · M. Ashida · R. Ishii
S. Abe · K. Ibukuro
Department of Radiology, Mitsui Memorial Hospital,
1 Kanda Izumicho Chiyoda-ku, 101-8643 Tokyo, Japan
E-mail: fkdhzm@jcom.home.ne.jp
Tel.: +81-03-3862-9111
Fax: +81-03-5687-9765

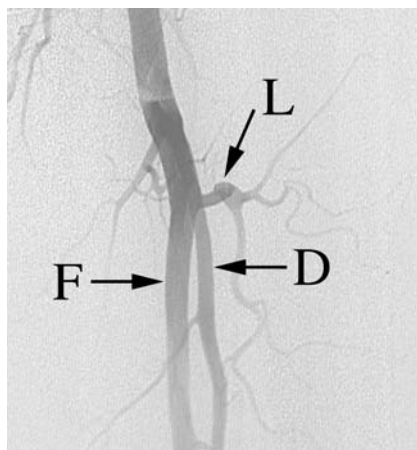


Fig. 1 Left femoral angiogram. Since the origin of the LFCAs was obscured in the hard copy because the DFA and FA were superimposed on each other, a frame with lower contrast was developed from videotape, and this allowed confirmation that the LFCAs originated from the FA. *D* DFA; *F* FA; *L* LFCAs

the 26 LFCAs that were used as an arterial graft for CABG in 26 patients was further assessed as a sub-group.

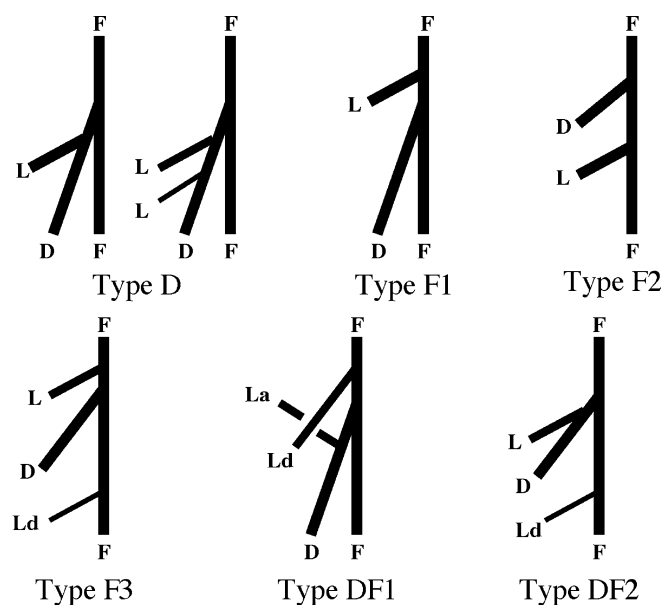


Fig. 2 Patterns of anatomical variation of the LFCAs. *Type D*: the LFCAs originate from the DFA, including a pattern in which the LFCAs originate from the DFA and a major branch of the LFCAs arises separately from the DFA; *type F1*: the LFCAs originate from the FA above the origin of the DFA; *type F2*: the LFCAs originate from the FA below the origin of the DFA; *type F3*: the LFCAs originate from the FA above the origin of the DFA and a major branch of the LFCAs arises from the FA below the origin of the DFA; *type DF1*: the descending branch of the LFCAs from the FA above the origin of the DFA and the ascending branch of the LFCAs arises from the DFA; *type DF2*: the LFCAs originate from the DFA and a major branch of the LFCAs arises from the FA below the origin of the DFA. *D* DFA; *F* FA; *L* LFCAs; *La* the ascending branch of the LFCAs; *Ld* the descending branch of the LFCAs

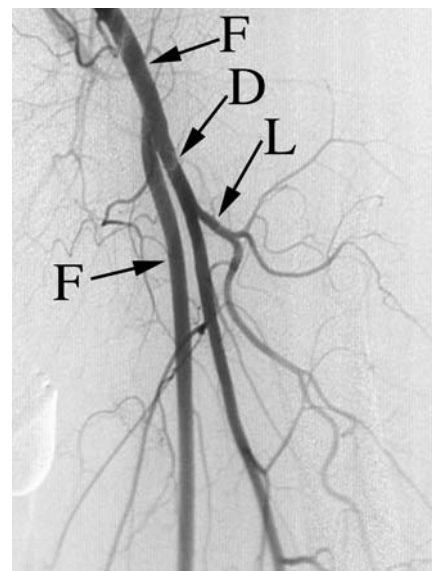


Fig. 3 Left femoral pattern of a type D LFCAs

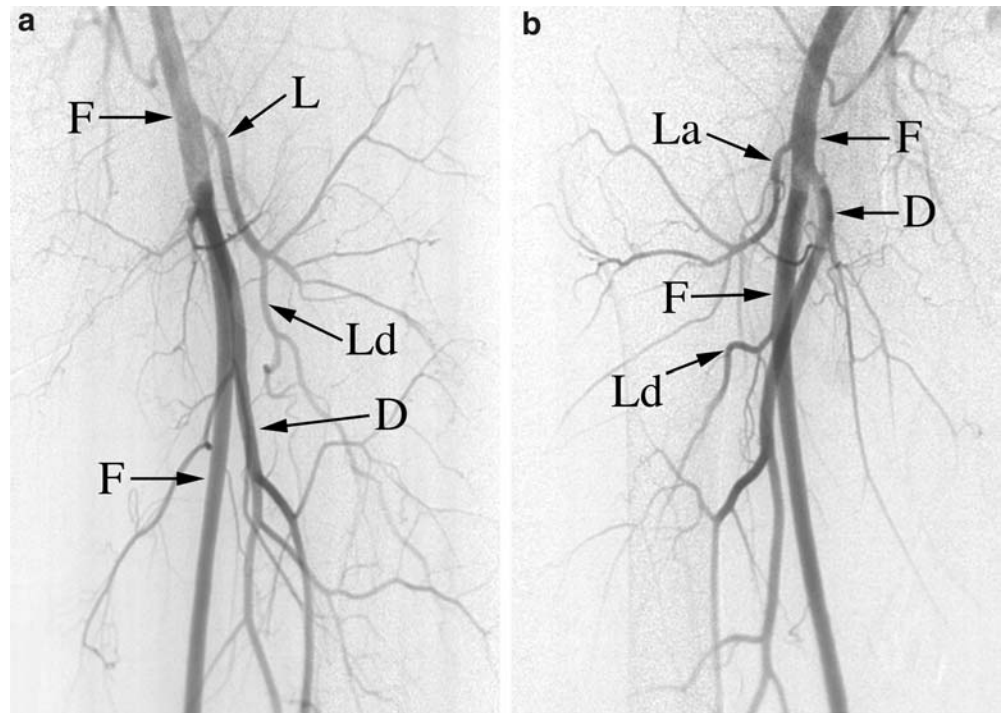
Results

The patterns of anatomical variation of the LFCAs in the 262 extremities studied were as follows: type D in 206 extremities (78.6%, Fig. 3), type F1 in 27 (10.3%, Fig. 4a), type F2 in 14 (5.3%, Fig. 5), type F3 in 4 (1.5%, Fig. 4b), type DF1 in 3 (1.1%, Fig. 6a) and type DF2 in 8 (3.1%, Fig. 6b). The patterns of anatomical variation of the 26 LFCAs that were used as an arterial graft for CABG were: type D in 24 (92.3%), type F1 in 1 (3.8%) and type F2 in 1 (3.8%). Hence, the type D LFCAs was most commonly chosen as an arterial graft for CABG, although there was no significant difference between the frequency of type D LFCAs in the overall population and in the sub-group of LFCAs chosen for use in CABG ($P = 0.10$, chi-square test).

Discussion

In the field of plastic and reconstructive surgery, the LFCAs has often been used to supply composite tissue as an anterolateral thigh flap [8, 9, 14], and in the field of cardiovascular surgery the LFCAs has been recognized as a new arterial conduit for CABG [5], since Tatsumi et al. [17] first reported a case in which the descending branch of the LFCAs was used as an arterial free graft for CABG. Since there are anatomical variants and individual differences in properties such as length and diameter of the branches of the LFCAs, arteriographic evaluation of the LFCAs is necessary before use [6]. At our institution, the descending branch of the LFCAs has been used as an arterial graft for CABG since 1997, and since that time bilateral femoral arteriography has been performed before surgery for patients in whom the use of the LFCAs might be justified. Based on the

Fig. 4 Bilateral femoral angiograms of the same patient. **a** Left femoral pattern of a type F1 LFCA. **b** Right femoral pattern of a type F3 LFCA



preoperative femoral arteriograms, we have analyzed anatomical variations of the LFCA by reviewing arteriograms from procedures performed since November 1998, when our latest angiographic instrument, which allows retrospective review using videotape, was installed.

The origin of the LFCA was frequently obscure in the hard copy images because the DFA and FA were superimposed anteroposteriorly [10, 12, 13]. In such cases, a frame with lower contrast was developed from

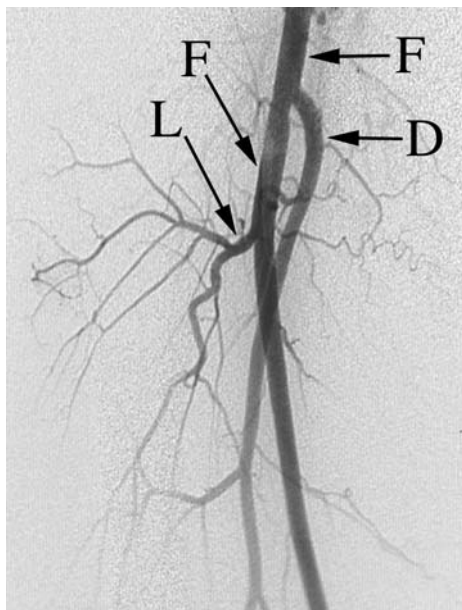
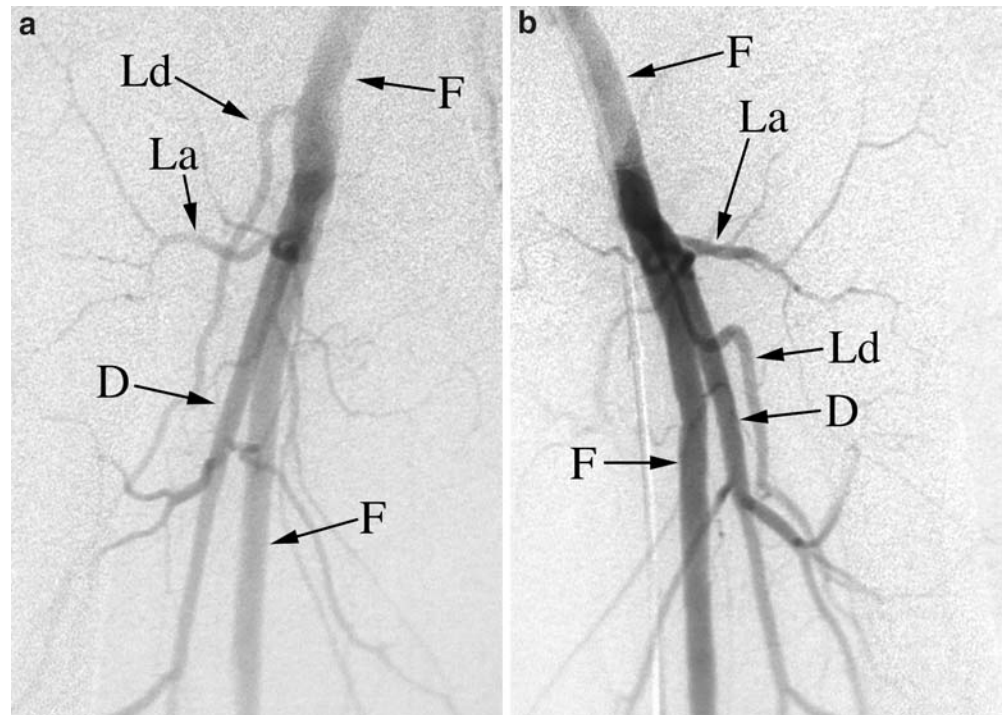


Fig. 5 Right femoral pattern of a type F2 LFCA

videotape to identify the precise origin of the LFCA (Fig. 1). Massoud et al. [12] have reviewed digital subtraction aortograms performed for demonstration of lower limb arteries in order to assess anatomical variants of the DFA. In the current study, we performed bilateral femoral arteriography separately on each side and additionally analyzed the variations using videotape, which permitted a more accurate anatomical evaluation.

As there was a tendency that the internal mammary artery [11], the radial artery [1] and the right gastroepiploic artery [16] were more frequently selected as an arterial graft than the LFCA in our institution, only 26 LFCAs were used for CABG in 26 of the 131 patients (19.8%). The type D LFCA occurred much more commonly (78.6%) than any of the other patterns, and LFCAs of type D were most commonly chosen as an arterial graft for CABG (92.3%), although there was no significant difference between the frequency of type D LFCAs in the overall group and that in the sub-group chosen for use in CABG ($P = 0.10$). One possible explanation for this finding is that LFCA variants other than type D are prone to develop an immature descending branch. It might be possible when an LFCA originates from two regions, such as a type F3, type DF1 or type DF2, that each branch tends to be underdeveloped. Indeed, no LFCA of type F3, type DF1 or type DF2 was applied as an arterial graft. On the other hand, since the appropriateness of an LFCA for use as an arterial graft for CABG is evaluated individually, and other factors also play a role in the decision, even a well-developed descending branch of a LFCA is not always used for arterial grafting. Hence, the usage frequency does not necessarily represent the degree of development

Fig. 6 Bilateral femoral angiograms of the same patient. **a** Right femoral pattern of a type DF1 LFCA. **b** Left femoral pattern of a type DF2 LFCA. *D* DFA; *F* FA; *L* LFCA; *La* the ascending branch of the LFCA; *Ld* the descending branch of the LFCA



of the descending branch of the LFCA. We did not perform quantitative or qualitative analysis of the degree of development of the descending branch of each LFCA.

Previous articles have classified anatomical variation of the DFA based on patterns of the LFCA and the medial femoral circumflex artery (MFCA) [2, 3, 10, 12, 13, 15, 18]. Although the MFCA is a significant artery in surgery of the proximal femur or hip [7], preoperative angiographic evaluations of the MFCA are not commonly used. In addition, identification of the origin of the MFCA on the angiogram is often difficult, since the MFCA is a smaller branch than the LFCA. Hence, we focused on the LFCA, since in addition this has recently been used as an arterial graft for CABG [5, 17], and preoperative anatomical assessment through arteriographic evaluation of the LFCA is now clinically indispensable in such procedures [6].

The type F3 LFCA has not been reported in the previous English literature illustrating schemata of anatomical patterns [3, 10, 12, 13, 18]. Type F3 LFCAs might previously have been categorized as type F1, because of failure to demonstrate that the branch of the LFCA originates from the FA below the origin of the DFA when using older angiography techniques with lower resolution [3, 12]. There might have been no discrimination between the FA above and below the origin of the DFA in previous reports [2, 18]. For example, the schemata described by Williams et al. [18] showing the LFCA, the descending branch of the LFCA and the DFA derived from the FA in order, defined as type 1b and type 1c, might have included the type F3 classification. In the Japanese literature, Emura et al. [4] reported a case with an illustration of a variant pattern

in accordance with a type F3 LFCA. In Adachi [2], a German anatomical textbook that was based on Japanese data, there are no illustrated schemata of anatomical patterns of the FA. Patterns in which the DFA and the MFCA make a common trunk and the LFCA originates directly from the FA, and in which the DFA, MFCA and LFCA all originate separately from the FA, might have included the type F3 LFCA.

All patients in the present study were Japanese, and most were male, because they were recruited from ischaemic heart disease patients who were eligible for CABG. The frequency of patterns other than type D that are defined as having an LFCA of direct origin from the FA was 21.4%, a similar result to that obtained (21.8%) by Adachi [2], also based on Japanese data (no data regarding gender were given by Adachi). Williams et al. [18] mentioned that the frequency of LFCAs of direct origin from the FA was 23.1% for white males, 23.1% for white females, 24.1% for black males and 23.3% for black females, indicating insignificant sex or race differences. Basar et al. [3] have reported conflicting results, suggesting that in Turkey the frequency of LFCAs of direct origin from the FA was significantly higher in women (46.2%) than in men (19.7%). No significant left- or right-sided predominance has been reported regarding the direct origin of the LFCA [15, 18].

Conclusion

We have presented anatomical data regarding the LFCA. The most common pattern consisted of an

LFCAs arising from the DFA, and there was a tendency for selection of LFCAs with such a pattern as arterial grafts for use in CABG.

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