The Incidence and Anatomy of Accessory Pudendal Arteries as Depicted on Multidetector-Row CT Angiography: Clinical Implications of Preoperative Evaluation for Laparoscopic and Robot-Assisted Radical Prostatectomy

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Objective: To help preserve accessory pudendal arteries (APAs) and to ensure optimal postoperative sexual function after a laparoscopic or robot-assisted radical prostatectomy, we have evaluated the incidence of APAs as detected on multidetector-row CT (MDCT) angiography and have provided a detailed anatomical description.

Materials and Methods: The distribution of APAs was evaluated in 121 consecutive male patients between February 2006 and July 2007 who underwent 64-channel MDCT angiography of the lower extremities. We defined an APA as any artery located within the periprostatic region running parallel to the dorsal vascular complex. We also subclassified APAs into lateral and apical APAs. Two radiologists retrospectively evaluated the origin, course and number of APAs; the final APA subclassification based on MDCT angiography source data was determined by consensus.

Results: We identified 44 APAs in 36 of 121 patients (30%). Two distinct varieties of APAs were identified. Thirty-three APAs (75%) coursed near the anterolateral region of the prostatic apex, termed apical APAs. The remaining 11 APAs (25%) coursed along the lateral aspect of the prostate, termed lateral APAs. All APAs originated from the internal obturator artery and iliac artery or a branch of the iliac artery such as the inferior vesical artery. The majority of apical APAs arose from the internal obturator artery (84%). Seven patients (19%) had multiple APAs.

Conclusion: APAs are more frequently detected by the use of MDCT angiography than as suggested by previous surgical studies. The identification of APAs on MDCT angiography may provide useful information for the surgical preservation of APAs during a laparoscopic or robot-assisted radical prostatectomy.

The incidence of prostate cancer has steadily increased in the last decade and prostate cancer now accounts for 25% of all cancers diagnosed in men in the United States; 186,320 new cases are expected in 2008 (1–4). The introduction by Walsh and Donker (5) of the nerve-sparing radical prostatectomy (RP) in 1982 and subsequent development of the procedure (6) has decreased the occurrence of postoperative erectile dysfunction after a RP for prostate cancer. However, population-based studies such as the Prostate Cancer Outcomes Study (7) have found that the rate of erectile dysfunction is still as high as 82% and 79% at two years and five years, respectively. Although the status of the cavernous nerve is a critical predictor of erectile function recovery postoperatively, some investigators have focused on the accessory pudendal arteries as the cause of arteriogenic erectile dysfunction (8–10). Contemporary anatomic and clinical studies indicate that the preservation of accessory pudendal arteries (APAs) has an important role in the maintenance of penile erectile function and continence after RP, although the relationship between APA preservation and post-operative functional outcomes remains equivocal (9, 11, 12). The incidence of 'large' lateral APAs has been reported as 4% for an open prostatectomy and 7% with the use of conventional angiography (11–13). Previous studies on laparoscopic RP suggest that endoscopic magnification results in a 6–7 fold increase in the APA detection rate (26–30%) and provides the additional benefit of a drier surgical field (14, 15). Furthermore, since the introduction of robot-assisted prostatectomy, the incidence of APAs has not been evaluated. Thus, the true incidence of APAs is unclear, as is their origin and course due to the narrow operation field. In the radiological literature, there is only a single study describing elective internal pudendal angiography, which was published in 1990 (13). Thus, the depiction of APAs by various imaging modalities such as multidetector-row computed tomography (MDCT) or magnetic resonance imaging (MRI) may provide useful information for preoperative evaluation.

In this study, we evaluate the incidence of APAs and provide a detailed anatomical description of their origin and course based on the use of MDCT angiography. Preservation of APAs can help to ensure optimal postoperative sexual function after a laparoscopic or robot-assisted laparoscopic RP.

MATERIALS AND METHODS

Patient Population

Our Institutional Review Board approved this retrospective study. Between March 2006 and July 2007, 230 consecutive patients underwent MDCT angiography of the lower extremities using a 64-MDCT scanner for imaging of arterial stenoocclusive disease with complication, trauma and postoperative graft surveillance of the legs. A total of 107 female patients and two male patients with inadequate arterial enhancement due to failure of peripheral arterial bypass grafts were excluded from the analysis. The remaining 121 male patients (mean age, 62.0–12.0 years; age range, 19–83 years) comprised the study population. Indications for MDCT angiography were chronic ischemia in 84 patients, acute ischemia in 30 patients and postoperative evaluation for placement of an arterial stent or bypass grafts in seven patients. Final diagnoses determined by the use of MDCT angiography were traumatic arterial injury including complete occlusion in three patients and pseudoaneurysm formation in one patient, patent arterial bypass grafts in seven patients that underwent postoperative graft surveillance and arterial stenoocclusive disease caused by atherosclerosis in 95 patients and caused by diabetes mellitus in 15 patients.

Multidetector-Row CT Scanning Technique

Multidetector-row CT angiography was performed using a 64-MDCT scanner (Brilliance 64, Phillips Medical Systems, Cleveland, OH). All patients were placed in the supine position with their feet entering the gantry first. Imaging was performed from the lower pole of the kidney to the toes. The scanning parameters used were as follows: tube voltage, 120 kV; effective tube current, 200 mAs with dose modulation (D-Dom, Phillips Medical Systems); rotation time, 0.5 seconds; collimation, 64×0.625 mm. The delay between contrast medium administration and the commencement of scanning was determined individually for each patient using standard bolus-tracking software (Automatic Bolus Tracking, Phillips Medical Systems). Scanning began 7 seconds after a threshold attenuation of 300 HU was reached in the suprarenal aorta. For each patient, 100 mL of iomeprol (400 mg I/mL Iomeron 400; Bracco, Milan, Italy) was injected via a 20-gauge angiographic catheter inserted into an antecubital vein. Contrast medium was injected monophasically at a rate of 5 mL/s.

Image Interpretation and Three-Dimensional Postprocessing

An APA was defined as any artery located within the periprostatic region running parallel to the dorsal vascular complex. The cavernous arteries, corona mortis and satellite arteries of the superficial and deep vascular complex were excluded from this definition. Two distinct

Table 1. Summary of Incidence of Types of Accessory Pudendal Arteries

	Single APAs (n = 29)	Multiple APAs		
		Bilateral Same (n = 5)	Bilateral Different (n = 1)	Three Different (n = 1)
Apical APAs	24	6	1	2
Lateral APAs	5	4	1	1

Note.— APA = accessory pudendal artery
Numbers in parentheses are numbers of patients.

varieties were subdivided as follows. 1) Lateral APAs were defined as coursing along the lateral aspect of the prostate and in intimate contact with the prostatic surface. 2) Apical APAs were defined as emerging near the anterolateral region of the prostatic apex close to the pubic bone. A retrospective review of all MDCT angiography source data was performed by consensus between two of the investigators (with 13 and seven years of board-certificated clinical experience in genitourinary and gastrointestinal radiology, respectively) as to the course, number and origin of the APAs. MDCT axial source images were evaluated and were used to evaluate the anatomy of the APAs. Some axial source images were processed on an Aquaris Workstation version 3.5.0.3 (TeraRecon, San Mateo, CA). During three-dimensional (3D) post processing, APAs were segmented by selection (clicking on the depictions with the computer mouse) and the segmented vessels were extended by dragging on the endpoints. Segmentation facilitated additional evaluation of the APAs, as it resulted in automatically generated curved multiplanar reformation images (Fig. 1).

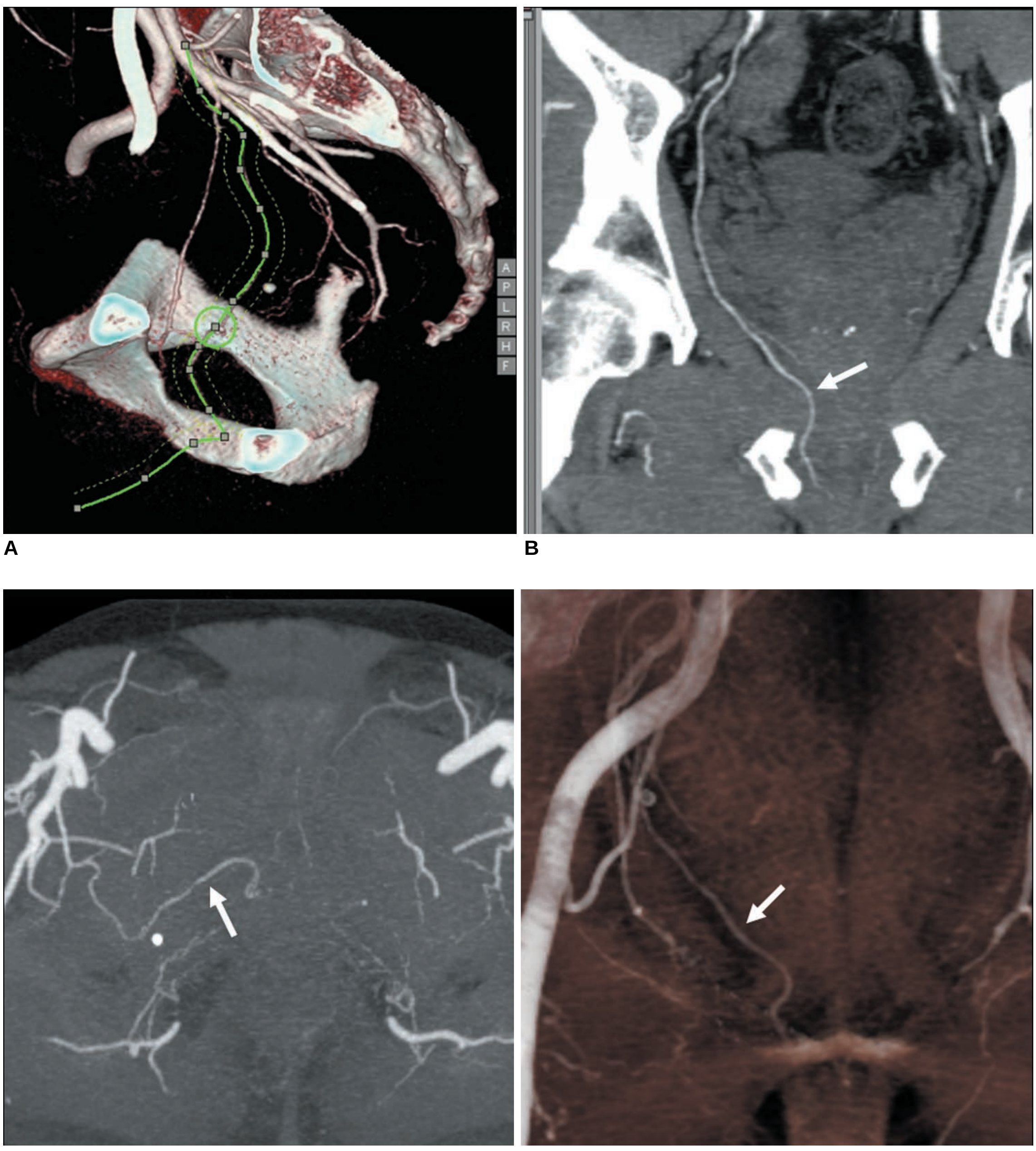

Fig. 1. Three-dimensional postprocessing images of accessory pudendal arteries (arrows) are shown.
A-D. Semi-automatic vessel segmentation of accessory pudendal artery (**A**), Automatic curved multiplanar reformation image (**B**), maximum-intensity-projection reconstruction image (**C**) and volume rendering image (**D**) are shown.

RESULTS

A total of 44 APAs were identified in 36 of 121 consecutive patients (30%). The APAs were on the right side in 23 (52%) patients and on the left side in 21 (48%) patients. All APAs were subclassified as lateral (Figs. 2, 3) and apical type APAs (Fig. 4): 11 lateral and 33 apical APAs were observed in nine and 29 patients, respectively. Among these APAs, multiple APAs were identified in seven patients (19%). Bilateral same APAs (bilateral lateral APAs in two patients and bilateral apical APAs in three patients) were present in five of 38 patients (14%). Bilateral different APAs were present in one patient (right, apical and left, lateral; 3%) and one patient had three different APAs (right, lateral and apical and left, apical; 3%) (Table 1).

The most common origin of the 44 APAs was the internal obturator artery (77%) (Fig. 5), followed by the iliac artery or a branch of the iliac artery such as the inferior vesical artery (23%) (Fig. 4). Apical APAs and lateral APAs most commonly originated from the internal obturator artery (28 of 33, 85% and 6 of 11, 55%, respectively).

DISCUSSION

Although an open RP for prostate removal remains the 'gold standard' due to accumulated experience and several long follow-up series (16, 17), the use of a laparoscopic or robot-assisted RP are now accepted surgical approaches for treatment of prostatic cancer and have become remarkably popular (18, 19).

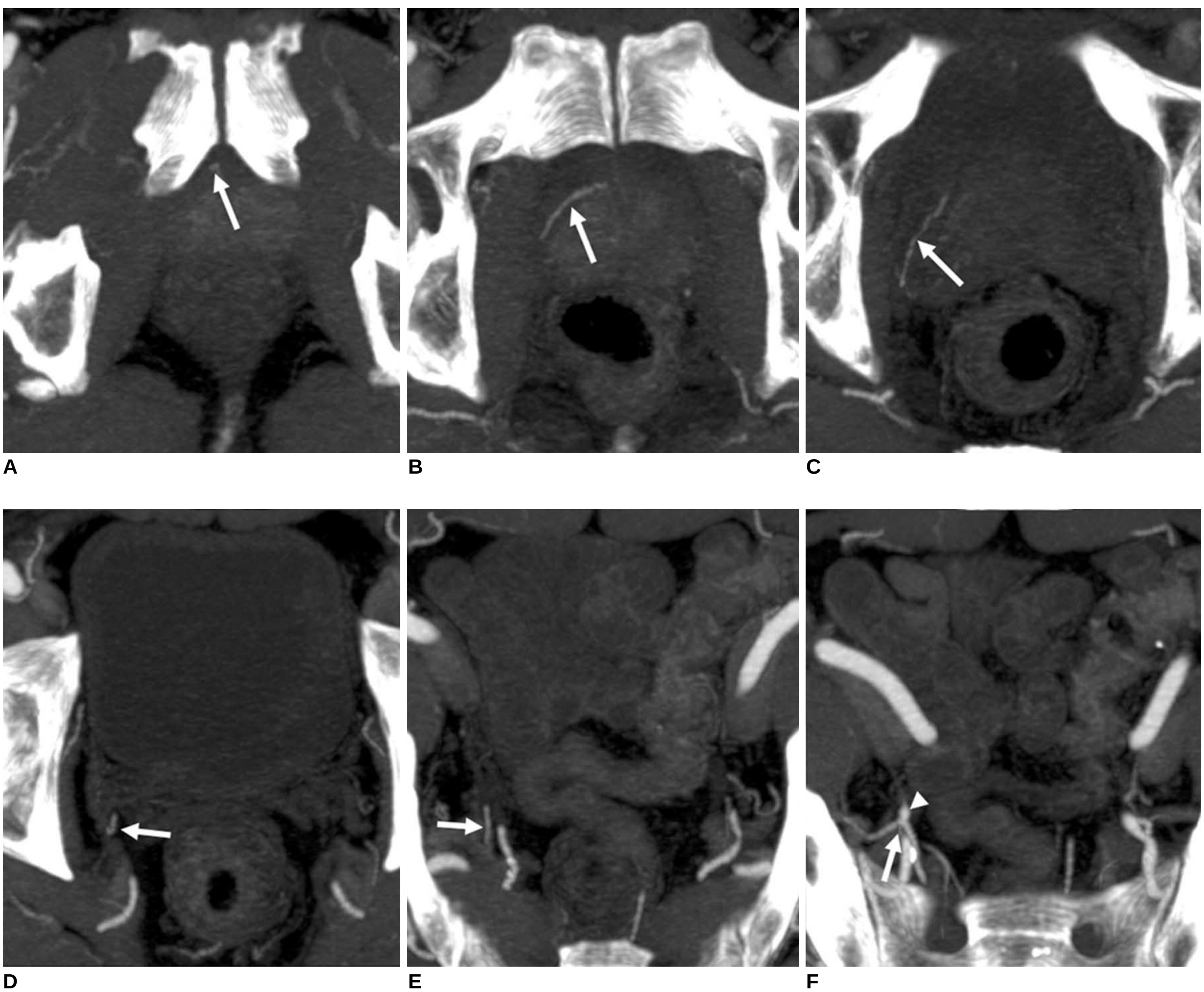

Fig. 2. Imaging findings are shown for 69-year-old male with lateral accessory pudendal artery arising from inferior vesical artery. Maximum-intensity-projection reconstruction images (**A-F**) show right lateral accessory pudendal artery (arrows) coursing along lateral aspect of prostate, which originates from left inferior vesical artery (arrowhead, bottom right).

Due to advances in optics, video technology and specialized instrumentation, the use of laparoscopic or robot-assisted RP has been able to reproduce the excellent results of open surgery with the advantage of minimal access. Both of these procedures decrease operation time and the development of oncologic, continence and potency-related complications (20–22). Another advantage of a laparoscopic or robot-assisted RP is the use of video-endoscopy, which magnifies the periprostatic anatomy by 10-fold to 15-fold. The use of video-endoscopy allows better preservation of the structures around the urinary sphincter (i.e., accessory pudendal artery), improved apical dissection and preservation of the neurovascular bundles (23, 24).

Current retrospective clinical studies suggest a possible connection between APA preservation and postsurgical functional outcomes, and a comprehensive understanding of APA anatomy has therefore been advocated (12). However, no study has provided data that allow definitive conclusions to be made about the relative merits of a laparoscopic or robot-assisted RP as compared with an open RP to avoid erectile dysfunction. The radiological literature describing the identification of APAs with incidence and anatomy has been limited (13, 25), even though more advanced imaging modalities such as MDCT or MR angiography can provide more accurate information.

The reported incidence of APAs based on conventional angiographic studies has ranged from 7% to 21% (13, 25). Breza et al. (26) and Benoit et al. (27) reported an incidence as high as 70% based on 10 and 20 cadaveric dissection series, respectively, but the incidence was only 4% for open RP series (11, 12). Recent laparoscopic RP

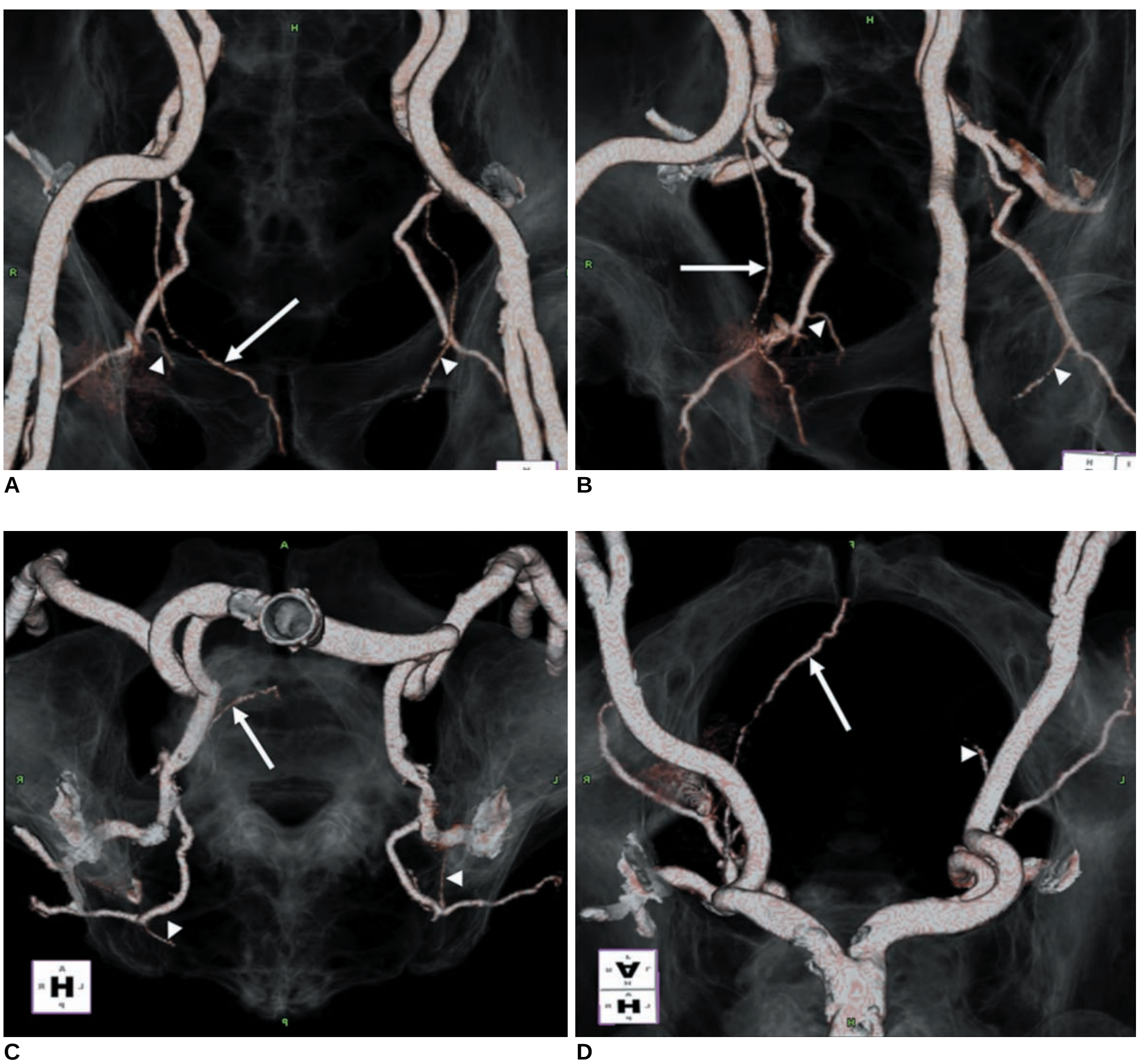

Fig. 3. Imaging findings are shown for 69-year-old male with lateral accessory pudendal artery arising from inferior vesical artery. Right lateral accessory pudendal artery (arrows) with proximal portion of bilateral internal pudendal artery (arrowheads) on transparent surrounding anatomy is readily recognized over right pelvic side wall on 3D postprocessing images (**A-D**) (top, anteroposterior and right anterooblique view; bottom, craniocaudal view).

series identified 92 APAs in 72 of 285 patients (25%) and 23 APAs in 18 of 70 patients (26%) (15, 24). In our study, the 44 APAs detected on MDCT angiography in 36 of 121 patients (30%) is a rate similar to the estimates based on laparoscopic series and the rate is much lower than estimates based on cadaveric studies. The variation in the incidence of APAs reported might be due to the modality used to identify the arteries. MDCT angiography may not be a very reliable method for the determination of the presence or absence of an APA. The true incidence of APAs might be greater than that reported in our study and laparoscopic series. Nevertheless, APAs identified on MDCT angiography may be sufficiently large to be preserved in the operation field for a laparoscopic or robot-assisted RP.

Secin et al. (24) have defined an APA as any artery located outside of the periprostatic region running parallel to the dorsal vascular complex and extending caudal toward the anterior perineum. These investigators identified two types of APAs depicted on laparoscopic images: one type coursing along the lateral aspect of the prostate or endopelvic fascia, which was termed as a lateral APA and

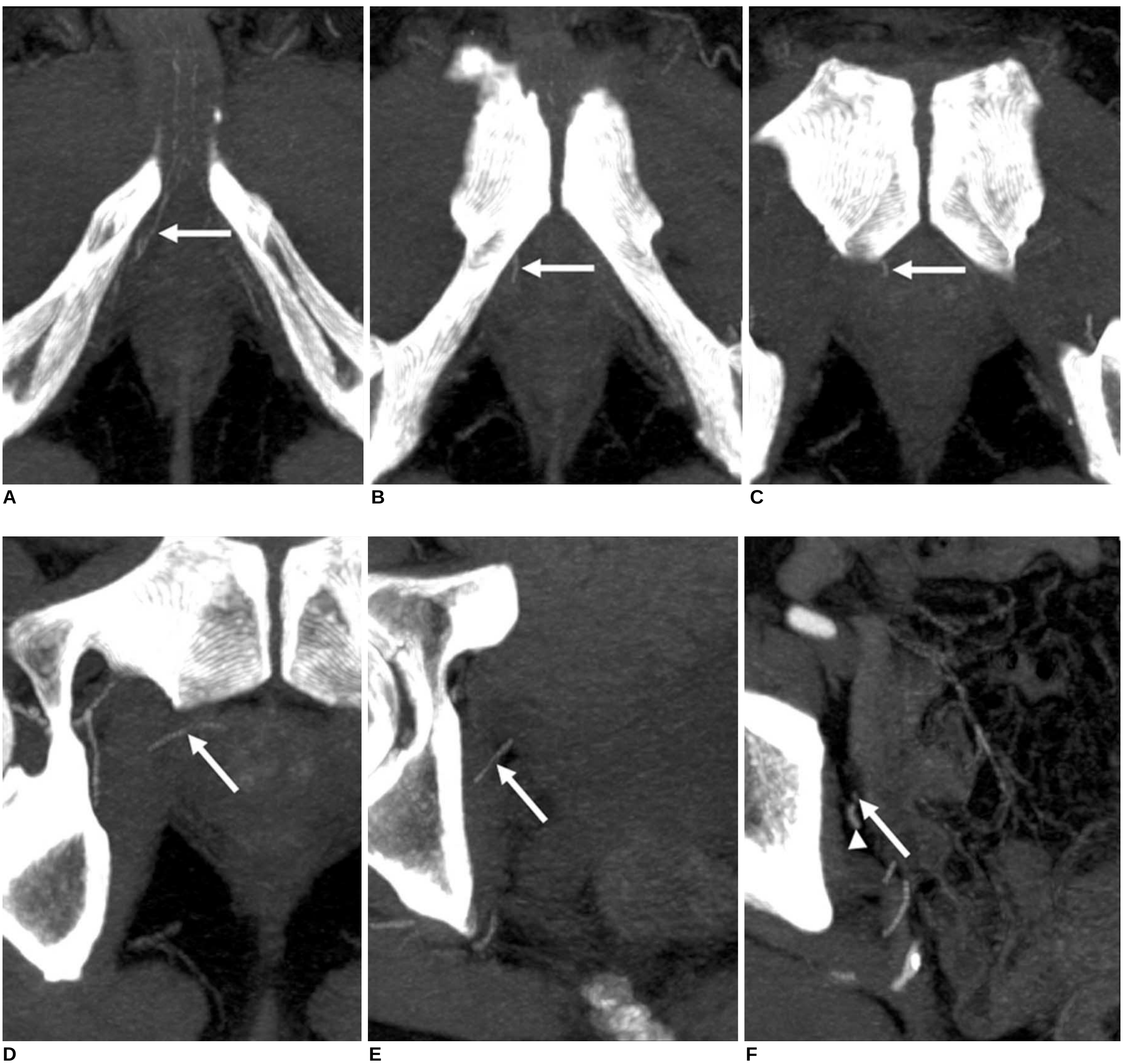

Fig. 4. Imaging findings are shown for 69-year-old male with apical accessory pudendal artery from inferior vesical artery. Maximum-intensity-projection reconstruction images (**A-F**) show right apical accessory pudendal artery (arrows) emerging near apical region of prostate, which originates from right inferior vesical artery (arrowhead, bottom right) with hairpin turn at dorsal vascular complex (top left).

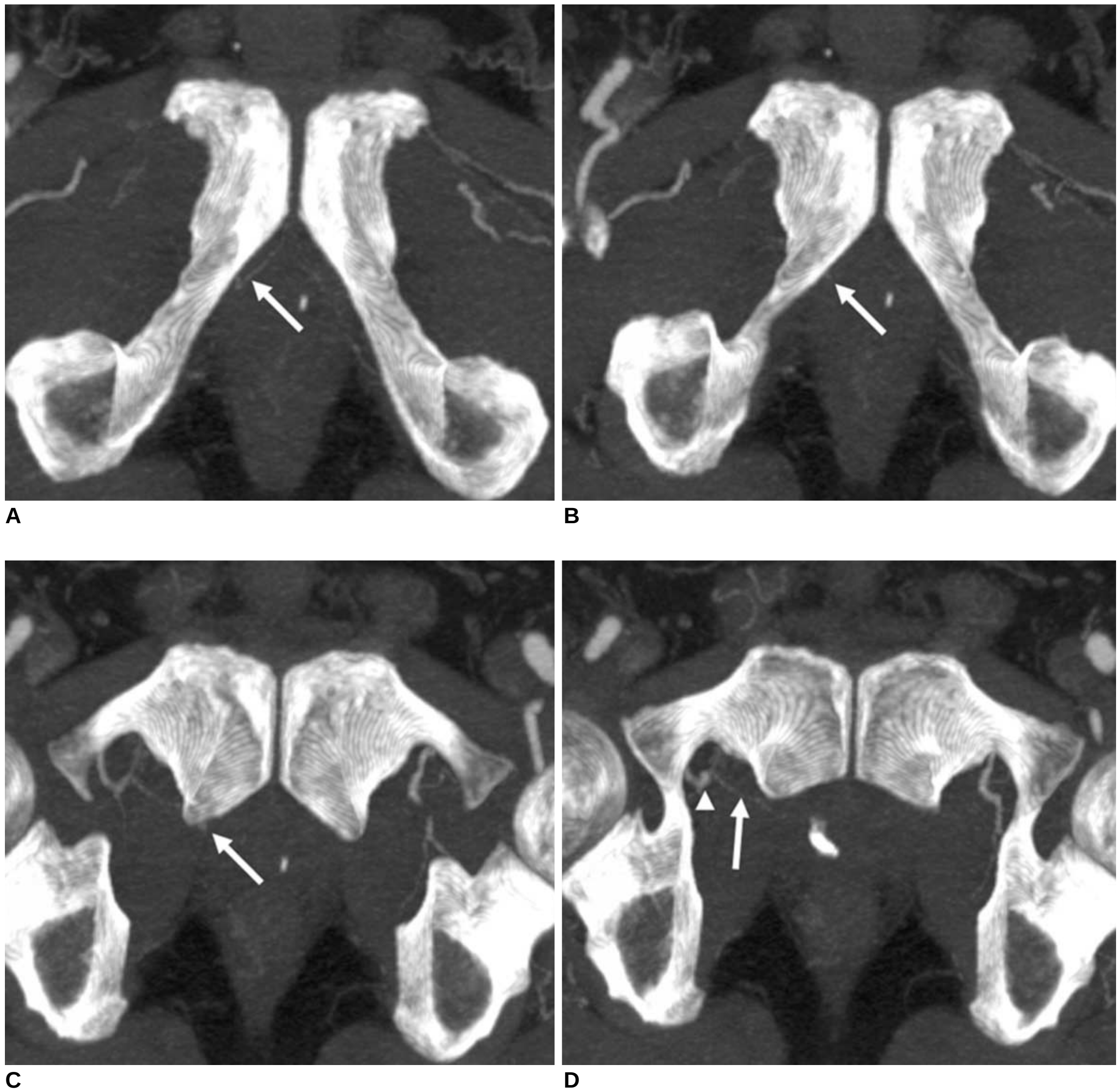

Fig. 5. Imaging findings are shown for 56-year-old male with apical accessory pudendal artery arising from internal obturator artery. Maximum-intensity-projection reconstruction images (**A-D**) show right apical accessory pudendal artery (arrows) that arose from right internal pudendal artery (arrowhead, bottom right) with hairpin turn at dorsal vascular complex (top left).

the other type originating near the apical region of the prostate, inferior and lateral to the puboprostatic ligament, which was termed as an apical APA. In the laparoscopic RP series of Secin et al. (14, 24, 28), 50–56% of the APAs identified were apical APAs and these arteries were present in 13% of all patients. These apical APAs presumably branched off either the obturator artery or the extrapelvic portion of the pudendal artery. Lateral APAs running above the endopelvic fascia usually branch off the inferior vesical artery or the hypogastric arteries, while lateral APAs running below the endopelvic fascia usually branch off the obturator artery (28). Matin (15) have identified 23 APAs in 18 patients (26%). In cadaveric dissections, Breza et al. (26) and Benoit et al. (27) reported that 50% and 36% of APAs originated from the ipsilateral obturator artery, respectively, and 13% and 46% from the inferior vesical artery, respectively, regardless of the APA variant type.

In our study, APAs traced on MDCT angiographic images could be subdivided according to the definitions described by Secin et al. (24, 28) based on cadaveric dissections. However, we modified diagnostic criteria used for a laparoscopic prostatectomy, as the anatomic landmarks such as the endopelvic fascia recognized in the operative field were not well identified on MDCT images. The definition of an APA was the same as for the laparoscopic and cadaveric studies. However, two distinct types of APAs based on MDCT images were defined as 'apical APAs' that emerge near the anterolateral region of the prostatic apex close to the pubic bone and 'lateral APAs' that course along the lateral aspect of the prostate in intimate contact with the prostatic surface. The incidence of apical APAs was 33 of 44 APAs (75%), present in 24% of all patients. The most common origin of APAs was the internal obturator artery (77% of all APAs and 85% of the apical APAs). These findings indicate a considerably higher prevalence of apical variants and various origins than previously reported for cadaveric and laparoscopic RP studies. The reasons for these differences are unclear, though they may be due to easily missed small APAs during surgery (15). The identification of apical APAs in the operative field is more challenging due to a smaller size and proximity to the dorsal vascular complex and the sphincteric complex; small apical APAs can be associated with a significantly lower rate of preservation (14).

This study has several limitations. First, intra-operative diagnosis by a laparoscopic or robot-assisted RP was not performed in all cases. However, we believe that tracing of small APAs by image trimming of MDCT images and 3D postprocessing is likely to provide more accurate information about the incidence and anatomical associations of APAs than observations based on the narrow fields during surgery. Second, our study did not have an independent standard of reference for detection of APAs. Very small APAs may be missed on MDCT images, particularly when suboptimal vascular enhancement or motion artifacts are present. Therefore, the prevalence of APAs in our study may underestimate the true prevalence. However, within the framework of surgical preservation, very small APAs that are missed may be less valuable for preoperative surveillance of APAs. Depending on the APA size, preoperative MR and MDCT angiography might be useful to determine standards of reference. Third, selection bias may be present in this study as MDCT angiography was used for preoperative or postoperative surveillance of limb ischemia and trauma in predominantly older patients with altered hemodynamics. However, if the age of candidates undergoing a prostatectomy is taken into consideration, the selection bias in this study is unlikely to affect the conclusions.

In conclusion, the prevalence and anatomic association of accessory pudendal arteries using MDCT angiography was estimated. We believe that MDCT angiography for preoperative surveillance of accessory pudendal arteries can be a feasible diagnostic option that may improve potency outcomes when used in conjunction with state-of-the-art surgical techniques such as a laparoscopic or robot-assisted laparoscopic RP.

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