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Chronic Total Occlusion Crossing Approach Based on Plaque Cap Morphology: The CTOP Classification

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Abstract

Purpose: To present the chronic total occlusion (CTO) crossing approach based on plaque cap morphology (CTOP) classification system and assess its ability to predict successful lesion crossing. **Methods:** A retrospective analysis was conducted of imaging and procedure data from 114 consecutive symptomatic patients (mean age 69±11 years; 84 men) with claudication (Rutherford category 3) or critical limb ischemia (Rutherford category 4–6) who underwent endovascular interventions for 142 CTOs. CTO cap morphology was determined from a review of angiography and duplex ultrasonography and classified into 4 types (I, II, III, or IV) based on the concave or convex shape of the proximal and distal caps. **Results:** Statistically significant differences among groups were found in patients with rest pain, lesion length, and severe calcification. CTOP type II CTOs were most common and type III lesions the least common. Type I CTOs were most likely to be crossed antegrade and had a lower incidence of severe calcification. Type IV lesions were more likely to be crossed retrograde from a tibiopedal approach. CTOP type IV was least likely to be crossed in an antegrade fashion. Access conversion, or need for an alternate access, was commonly seen in types II, III, and IV lesions. Distinctive predictors of access conversion were CTO types II and III, lesion length, and severe calcification. **Conclusion:** CTOP type I lesions were easiest to cross in antegrade fashion and type IV the most difficult. Lesion length >10 cm, severe calcification, and CTO types II, III, and IV benefited from the addition of retrograde tibiopedal access.

Keywords

antegrade access, critical limb ischemia, chronic total occlusion, peripheral artery disease, plaque cap, plaque morphology, retrograde access, tibiopedal access

Introduction

Peripheral artery disease (PAD) is a worldwide epidemic affecting millions of patients.[1] Critical limb ischemia (CLI) is considered the most advanced stage of PAD. Chronic total occlusions (CTOs) are commonly seen in the femoropopliteal segment of patients with PAD and intermittent claudication, while patients with CLI classically have a multilevel distribution of arterial disease. CTOs represent dense collagenous lesions with varying degrees of calcification obstructing blood flow to distal vascular beds. The obstructive nature of this material limits the success rate of traversing these CTOs during catheter-based interventions.

The true length of a CTO cannot be determined with angiography alone because the column of contrast cannot penetrate the "caps" located at the proximal and distal ends of the occlusion. Thus, lesions may appear angiographically to be longer than they truly are[2,3] as the contrast stops at the proximal cap and does not reconstitute until a collateral artery is able to restore flow distally. This has prompted the

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use of duplex ultrasound whenever feasible to identify the CTO caps and better quantify lesion length.

Another tool to increase the likelihood of success in patients with complex disease is the use of retrograde tibiopedal access.[4–6] It is generally accepted that a "hibernating" (patent) lumen may be present within the space between the proximal and distal caps. This can be observed when crossing CTOs with ultrasound guidance because the wire (or crossing device) moves freely after traversing the cap while maintaining its intraluminal path. If a distal cap can be penetrated with greater ease than the proximal cap, it may facilitate successful treatment.

The CTO crossing approach based on plaque cap morphology (CTOP) study was designed to determine if the cap morphologies determined from analysis of angiograms and duplex studies performed in PAD patients can be used to predict the success of different interventional approaches (antegrade vs retrograde vs combined antegrade-retrograde) in traversing CTOs.

Methods

Study Design

A retrospective analysis was conducted of imaging and procedure data from 114 consecutive symptomatic patients (mean age 69±11 years; 84 men) who were enrolled in the Peripheral Registry of Endovascular Clinical Outcomes (PRIME) following an endovascular intervention. The registry design and early findings of the first 328 patients enrolled have been previously reported.[7]

Patients were eligible for this study if they had Rutherford category 3–6 ischemia and a CTO of one or more lower extremity arteries identified by duplex ultrasound and/or angiography prior to intervention (within 90 days). If duplex imaging was not feasible secondary to severe calcification, then angiography was the only modality used for this study. The determination of severe calcification was based on a >5-cm-long segment of calcium identified on both sides of the artery or acoustic shadowing prohibiting visualization of the vessel lumen or cap morphology on duplex.

Morphological Assessment and the CTOP Classification

Data were collected to compare CTO cap morphology as defined by the CTOP classification system and crossing success based on the location and number of arterial access sites. All images were analyzed by at least 2 physicians. The morphology (concave or convex) of the proximal and distal CTO caps was based on their appearance during a systolic frame of real-time ultrasound (color duplex and/or power mode Doppler) and/or angiographic imaging loops assuming flow in a cranial-caudal direction. Figure 1 demonstrates a superficial femoral artery (SFA) with a proximal concave CTO cap (approached in a traditional antegrade fashion) as delineated by angiography and duplex ultrasound. The distal CTO cap appears convex when visualized from a cranial-caudal direction.

There are 4 possible combinations of proximal and distal CTO caps (Figure 2). The different combination of caps has been assigned a number from I to IV with higher numbers representing a hypothetical increase in lesion complexity that would render these lesions as increasingly more difficult to cross from a traditional antegrade approach. When describing the caps from an antegrade approach, type I has concave proximal and distal caps, type II has a concave proximal and a convex distal CTO cap, type III has convex proximal and concave distal CTO caps, and type IV has convex proximal and distal caps. The classification itself does not take into consideration the length of the occlusions, amount of calcium, or the presence and quality of collateral arteries between the proximal and distal CTO caps.

Access Sites and Crossing Direction

The number of arterial access sites and the direction to cross the CTO (antegrade vs retrograde) was at the discretion of the operator. Access sites may have included contralateral retrograde common femoral artery (CFA), antegrade CFA, and/or retrograde tibiopedal arteries. In some cases, the initial approach was a combined antegrade-retrograde strategy based on CTO length, calcification severity, and cap morphology. This planned dual access was defined as a combination of CFA access (either ipsilateral antegrade or contralateral retrograde with the "up and over" strategy) plus retrograde tibiopedal access, which indicates that the operator *chose to start* the case by accessing both arterial sites prior to attempting to cross the CTO.

If the original CTO crossing strategy failed using the initial access site (CFA or tibiopedal) then access conversion was necessary to obtain an extra arterial access to cross and treat the lesion. In most cases, access conversion represented the need to obtain tibiopedal access.

Crossing Strategies

CTO crossing was performed under fluoroscopic and/or extravascular ultrasound (EVUS) guidance. The crossing strategies were documented based on the direction from which the crossing tools (wires, catheters, and/or CTO crossing devices) were used to achieve success. Hence, crossing strategies were classified as "antegrade," "retrograde," and "antegrade-retrograde." If crossing tools from either direction were in the subintimal space or true lumen and required the simultaneous use of antegrade and

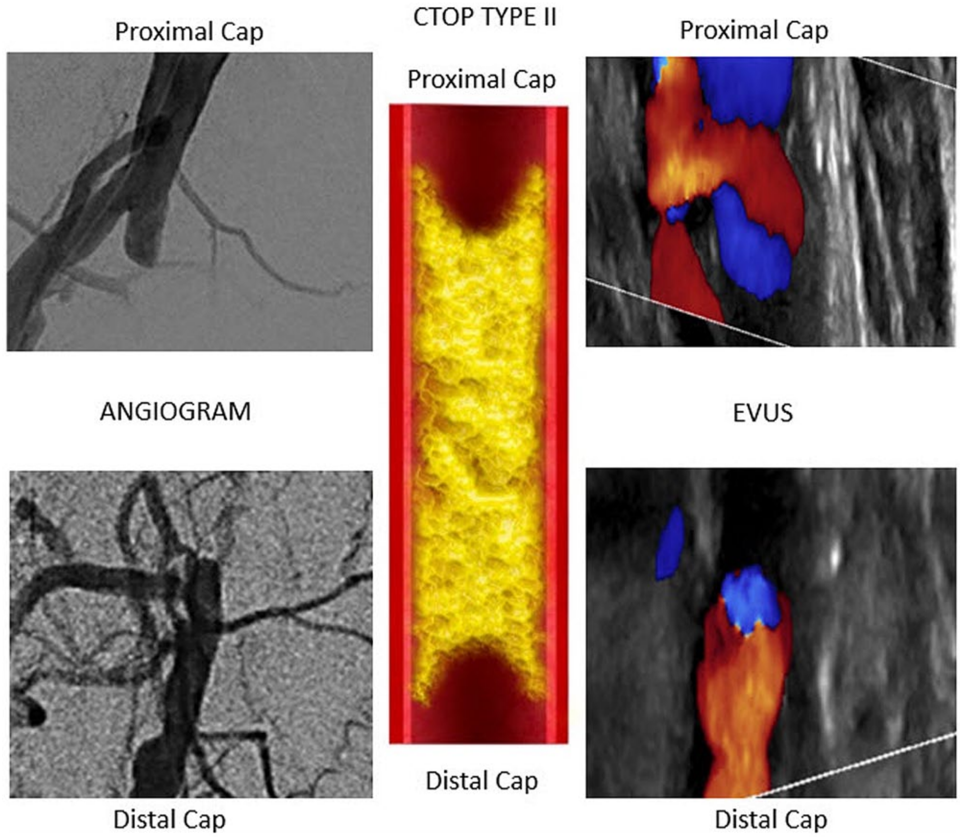

Figure 1. The caps of a superficial femoral artery chronic total occlusion (CTO) as imaged by angiography (left) and extravascular ultrasound (EVUS; right) surround an illustration of cap morphology depicting the concave proximal cap and the convex distal cap.

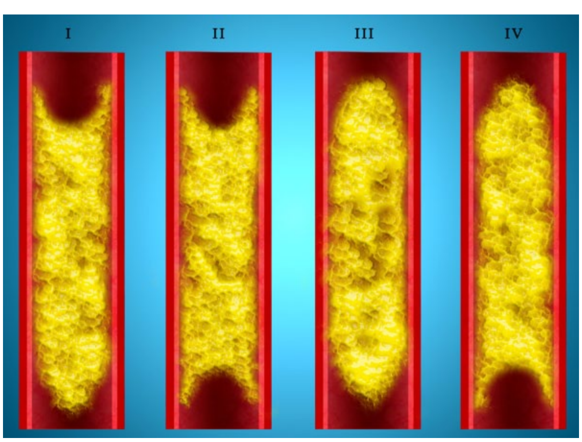

Figure 2. The chronic total occlusion crossing approach based on plaque cap morphology (CTOP) classification. Type I has 2 concave caps when evaluating from the cranial to caudal flow. Type II has a concave proximal cap and a convex distal cap. Type III has a convex proximal and concave distal cap. Type IV has 2 convex caps.

retrograde devices (whether planned or not), the strategy was classified as "advanced technique." Three potential advanced techniques were identified: SAFARI (subintimal arterial flossing with antegrade-retrograde intervention),[8] tunneling (passing a 0.014-inch wire from an antegrade or retrograde catheter into an 0.035-inch catheter approaching from either the retrograde or antegrade access point), or revascularization utilizing antegrade reentry into a retrograde balloon using the Outback LTD Re-Entry Catheter (Cordis Corporation, a Cardinal Health company, Milpitas, CA, USA).[9]

Statistical Analysis

Data are reported on a per lesion basis as the means ± standard deviation for continuous variables and counts (percentage) for categorical data. Comparisons among CTO types were carried out with analysis of variance or Fisher exact tests; Bonferroni-adjusted pairwise comparisons were performed given an omnibus $p<0.05$. The kappa statistic was applied to assess agreement of CTO type between

Table 1. Demographics and Comorbidities According to the CTOP Classification.[a]

Variable	CTOP Classification of 142 CTOs				p
	I (n=28)	II (n=52)	III (n=20)	IV (n=42)	
Age, y	69±10	70±10	73±13	67±10	0.12
Men	20 (71)	39 (75)	16 (80)	35 (83)	0.65
Dyslipidemia	28 (100)	50 (96)	18 (90)	40 (95)	0.37
Hypertension	23 (82)	45 (87)	16 (80)	36 (86)	0.86
Diabetes	19 (68)	36 (69)	12 (60)	32 (76)	0.61
Claudication	23 (82)	47 (90)	15 (75)	38 (91)	0.27
Resting pain	21 (75)	29 (56)	13 (65)	17 (41)	0.03[b]
Ulcer	12 (43)	21 (40)	10 (50)	19 (45)	0.90
Rutherford category					0.13
3	6 (21)	16 (31)	5 (25)	19 (45)	
4	12 (43)	16 (31)	5 (25)	4 (10)	
5	8 (29)	17 (33)	9 (45)	16 (38)	
6	2 (7)	3 (6)	1 (5)	3 (7)	
Creatinine, mg/dL	1.4±0.4	1.3±0.6	1.2±0.2	1.4±0.7	0.52
>1.5 mg/dL	9 (32)	7 (14)	2 (10)	10 (24)	0.14
Hemoglobin, g/dL	12.3±2.1	12.0±1.9	12.1±2.0	12.3±1.9	0.81
Lesion length, cm	13±10	28±13	26±13	25±12	<0.001[c]
Severe calcification	4 (14)	27 (52)	17 (85)	24 (57)	<0.001[c]

Abbreviations: CTO, chronic total occlusion; CTOP, chronic total occlusion crossing approach based on plaque cap morphology.
[a]Continuous data are presented as the means ± standard deviation; categorical data are given as the counts (percentage).
[b]Type I vs type IV by a Bonferroni-adjusted pairwise comparison.
[c]Type I vs types II, III, and IV by a Bonferroni-adjusted pairwise comparison.

angiography and ultrasonography. Logistic regression was used to evaluate the relationship of baseline characteristics to the lesion crossing approach. Variables achieving p<0.1 in the univariate model were loaded into in a multivariable model using a forward-backward stepwise elimination variable selection process that optimized the Akaike information criterion by assessing model fit penalized for the number of estimated parameters. Outcomes of logistic regression are reported as the odds ratio (OR) with 95% confidence interval (CI). The threshold of statistical significance was p<0.05. Data were analyzed using Predictive Analytics software (version 22; IBM Corporation, Armonk, NY, USA) and R (version 3.3.2; R Foundation for Statistical Computing, Vienna, Austria; *http://www.r-project.org*).

Results

The type of CTO was documented by both duplex and angiography in 50.7% of the cases (72/142). Operators used EVUS in 96 (67.6%) cases but not all CTO caps were able to be analyzed due to calcium burden. Overall, the documented agreement between EVUS and angiography to characterize a CTO was 83%. The kappa correlation coefficient was 0.76, suggesting excellent correlation.

Baseline variables that demonstrated statistically significant differences among CTO types were (1) the presence of ischemic rest pain, which was more prevalent among patients presenting with CTOP type I lesions vs type IV (p=0.03); (2) shorter lesion length in CTOP type I CTOs (<0.001); and (3) lower incidence of severe calcification (p<0.001) in CTOP type I lesions vs any of the other lesion types (Table 1). The CTOs had a mean lesion length of 24±13 cm, varying between 13 cm for type I lesions and 28 cm for type II. Type II CTOs were also the most common (52/142, 36.6%), while type III CTOs were identified in only 14.1% (20/142) of lesions. Half the CTOs had severe calcification (Table 1).

Distribution of access sites for each type of CTO, direction of CTO crossing (antegrade, retrograde, or advanced techniques), and crossing strategy can be seen in Table 2. Planned dual access was the chosen strategy in nearly one-third of the cases (45/142) and most commonly seen in types II, III, and IV CTOs. Access conversion was used in 23.2% of the cases (33/142), most commonly in types II, III, and IV CTOs. The univariate predictors of access conversion (Table 3) were CTO type III (OR 11.25, p=0.03), CTO type II or III (OR 3.39, p=0.006), lesion length per 10 cm (OR 2.04, p<0.001), lesion length >10 cm (OR 4.96, p=0.007), and severe calcification (OR 9.9, p<0.001). In multivariate analysis, lesion length per 10 cm (OR 1.82, p=0.005) and severe lesion calcification (OR 7.96, p<0.001) remained statistically predictive of access conversion.

Five CTOs were not successfully crossed with a wire or device including 3 CTOs with type III classification.

Table 2. Access Site and Crossing Details Compared by CTOP Type.[a]

Variable	CTOP Type				p
	I (n=28)	II (n=52)	III (n=20)	IV (n=42)	
Access type					<0.001[b,c]
Retrograde pedal	0	4 (8)	2 (10)	16 (38)	
Antegrade	21 (75)	19 (37)	3 (15)	9 (21)	
Planned dual	0	18 (35)	14 (70)	13 (31)	
Retrograde CFA	7 (25)	11 (21)	1 (5)	4 (10)	
Access conversion					<0.001[b,d]
Yes	0	15 (29)	5 (25)	13 (31)	
No	28 (100)	19 (37)	1 (5)	16 (38)	
Crossing success	28 (100)	51 (98)	17 (85)	41 (98)	0.04
Direction crossed[e]					<0.001[b,f,g]
Antegrade	28 (100)	20 (39)	0	3 (7)	
Retrograde	0	5 (10)	1 (5)	25 (60)	
Advanced technique	0	26 (50)	16 (80)	13 (31)	
Crossing location[e]					<0.001[b,h]
True lumen	24 (86)	17 (33)	2 (10)	27 (64)	
Subintimal	0	30 (58)	14 (70)	12 (29)	
Unknown	4 (14)	4 (8)	1 (5)	2 (5)	
Advanced technique[e]	0	26 (51)	16 (94)	13 (32)	<0.001[b,i]
EVUS guidance	12 (43)	38 (73)	14 (70)	32 (76)	0.02[j]
Device used	7 (25)	20 (39)	4 (20)	14 (33)	0.42
Device success	7 (25)	7 (14)	0	4 (10)	0.07
Catheter or wire used	21 (75)	44 (85)	16 (80)	38 (91)	0.34

Abbreviations: CFA, common femoral artery; CTOP, chronic total occlusion crossing approach based on plaque cap morphology; EVUS, extravascular ultrasound.
[a]Data are given as the counts (percentage); p value based on a Bonferroni-adjusted pairwise comparison.
[b]Type I vs types II, III, and IV.
[c]Type II vs type IV.
[d]p value based on yes/no responses only.
[e]Denominators include patients with successful crossing only.
[f]Type II vs types III and IV.
[g]Type III vs type IV.
[h]Type IV vs types II and III.
[i]Type III vs types II and IV.
[j]Type I vs type IV.

Successful antegrade crossing was documented in 37.2% (51/137) of the cases, with type I CTO being the most commonly crossed in this fashion (100%). Retrograde crossing was achieved in 22.6% (31/137) of the cases, most often in type IV CTOs (25/42, 60.0%). Advanced techniques had to be used in 40.1% (55/137) of the cases. CTO crossing devices were used in nearly one-third of the cases (45/142, 31.7%) but were successful only 40% of the time (Table 2).

With regards to the likelihood of crossing a lesion from an antegrade (traditional) approach, a univariate analysis (Table 4) showed that the odds of successful antegrade crossing decreased as lesion complexity increased. Type I CTOs were the least likely to be crossed in retrograde fashion (OR 0.3, p=0.01), while type IV CTOs were the most likely (OR 2.87, p=0.02). Type III CTOs were associated with the highest statistical likelihood (based on Bonferroni-adjusted pairwise comparisons against types II and IV) of requiring the use of advanced techniques and reentry, making it the most complex type of lesion to cross.

Discussion

To the best of our knowledge, no one has heretofore attempted to classify lower extremity CTOs based on the morphology of their proximal and distal caps and correlate the CTO cap characteristics with the likelihood of using the traditional antegrade approach to cross the lesion. This clinical application of the proposed CTOP classification is of paramount importance as it could allow operators to plan an endovascular strategy encompassing access, crossing, and treatment from the beginning of the case. This could translate into time savings, improved efficiency, and decreased radiation and contrast exposure. By using a combination of EVUS guidance along

Table 3. Univariate and Multivariate Predictors of Access Conversion Based on CTOP Type, Lesion Length, and Comorbidities.

Variable	Unit of Measure	Odds Ratio (95% CI)
Univariate		
CTO type I	Yes/no	—[a]
CTO type II	Yes/no	1.97 (0.83 to 4.71) p=0.13
CTO type III	Yes/no	11.25 (1.26 to >100) p=0.03
CTO type IV	Yes/no	1.95 (0.79 to 4.79) p=0.15
CTO type II or III	Yes/no	3.39 (1.41 to 8.13) p=0.006
Lesion length	Per 10 cm	2.04 (1.39 to 2.99) p<0.001
Lesion length >10 cm	Yes/no	4.96 (1.56 to 15.80) p=0.007
Severe calcium density	Yes/no	9.90 (3.53 to 27.74) p<0.001
Diabetes	Yes/no	0.86 (0.36 to 2.05) p=0.74
Chronic kidney disease	Yes/no	0.69 (0.25 to 1.86) p=0.46
Critical limb ischemia	Yes/no	0.55 (0.23 to 1.30) p=0.17
Below-the-knee vessel	Yes/no	0.70 (0.27 to 1.83) p=0.47
Multivariate		
Severe calcium density	Yes/no	7.96 (2.72 to 23.28) p<0.001
Lesion length	Per 10 cm	1.82 (1.20 to 2.77) p=0.005

Abbreviations: CI, confidence interval; CTO, chronic total occlusion.
[a]Not calculable due to zero events in 1 group.

Table 4. Univariate Predictors of Antegrade and Retrograde Crossing.[a]

Variable	Unit of Measure	Antegrade Crossing	Retrograde Crossing
CTO type I[b]	Yes/no	3.97 (1.50 to 10.51) p=0.006	0.30 (0.11 to 0.79) p=0.01
CTO type II	Yes/no	1.27 (0.55 to 2.91) p=0.58	0.95 (0.41 to 2.18) p=0.90
CTO type III	Yes/no	0.92 (0.18 to 4.79) p=0.92	1.24 (0.24 to 6.45) p=0.80
CTO type IV[c]	Yes/no	0.23 (0.09 to 0.57) p=0.002	2.87 (1.20 to 6.84) p=0.02
CTO type II or III	Yes/no	1.22 (0.55 to 2.73) p=0.62	1.00 (0.45 to 2.24) p>0.99
Lesion length	Per 10 cm	0.87 (0.64 to 1.18) p=0.36	1.20 (0.88 to 1.63) p=0.26
Lesion length >10 cm	Yes/no	0.65 (0.28 to 1.51) p=0.31	1.91 (0.80 to 4.56) p=0.15
Severe calcium density	Yes/no	1.39 (0.63 to 3.05) p=0.41	0.77 (0.35 to 1.70) p=0.52
Diabetes	Yes/no	0.80 (0.35 to 1.82) p=0.59	1.04 (0.46 to 2.35) p=0.93
Chronic kidney disease	Yes/no	0.81 (0.33 to 2.00) p=0.64	1.46 (0.59 to 3.61) p=0.42
Critical limb ischemia	Yes/no	2.71 (1.18 to 6.25) p=0.02	0.51 (0.23 to 1.16) p=0.11
Below-the-knee vessel	Yes/no	1.46 (0.61 to 3.48) p=0.40	0.66 (0.28 to 1.61) p=0.37

Abbreviation: CTO, chronic total occlusion.
[a]Data are presented as the odds ratio (95% confidence interval).
[b]Multivariate analysis showed least likely to be crossed retrograde.
[c]Multivariate analysis showed least likely to be crossed antegrade.

with a preplanned retrograde tibiopedal access, complication rates could also decrease.[4,10,11]

Recently, the use of retrograde tibiopedal access has been gaining favor as a tool to complement traditional revascularization techniques, especially in patients with CLI.[4,9] This observation included the use of EVUS to guide arterial access and interventions, which has been shown to decrease the rate of complications, exposure to fluoroscopy, and amount of iodinated contrast administered.[10–16] The incorporation of the CTOP classification, EVUS guidance, and retrograde tibiopedal access (for CTOP types II, III, and IV lesions) as part of the routine approach to CTO treatment is important for procedural success and decreased complications given the complexities of these patients, who often require multiple revascularization procedures to achieve complete symptom resolution or wound healing.[17]

EVUS-guided retrograde tibiopedal access was used in more than two-thirds of cases and was a determining factor in increasing the success rate of crossing and treating the CTOs: 22% of CTOs were crossed in retrograde fashion and 39% were crossed using combined antegrade-retrograde/advanced techniques. This practice is further supported by recently published data from the PRIME registry regarding the use of EVUS to guide arterial puncture in 896 access

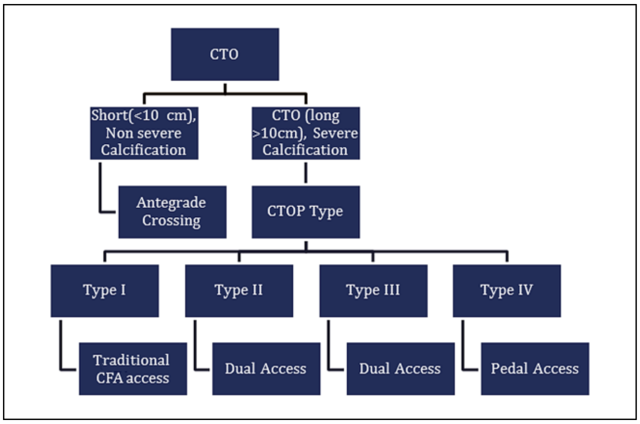

Figure 3. A proposed crossing algorithm using the type of chronic total occlusion (CTO) crossing approach based on plaque cap morphology (CTOP) classification and preferable approach for arterial access. CFA, common femoral artery.

points (345 of which were tibiopedal sites). The rate of significant bleeding among these was 0%. The only complication reported was pseudoaneurysm formation of the distal anterior tibial artery, which resolved with manual compression, resulting in a 0.3% complication rate.[7] This compared favorably to the <1% vessel thrombosis, dissection, or hematoma formation rate reported in a multicenter registry examining outcomes related to tibiopedal access in 197 patients.[10]

Current practice is characterized by the use of tibiopedal access as a last resort. Failure rates in crossing CTOs have ranged from 20% to 40%,[4–6,8,18] and most operators do not attempt retrograde tibiopedal access unless a traditional attempt to cross the CTO in antegrade fashion has already been pursued. This "traditional" approach provides a false sense of security and could arguably be harmful in some instances given that after a failed antegrade attempt most physicians tend to stop and reschedule the patient for another procedure. This predisposes the patient to another hospitalization, puncture, potential exposure to anesthesia, and other inherent potential complications.

The findings of the PRIME registry suggest that the use of retrograde tibiopedal access is safe and therefore may be effective in aiding the crossing of complex CTOs (types II, III, and IV).[7] Previously published data suggest that it can also be used to cross CTOs *and* deliver therapy exclusively in retrograde fashion without the need for a concomitant antegrade access ("TAMI technique").[4]

Figure 3 depicts the proposed crossing algorithm based on the CTOP classification. Long (>10 cm) and heavily calcified CTOs tend to require the use of an additional retrograde tibiopedal access. Relatively short type I CTOs appear to have the highest rate of crossing success with the traditional antegrade approach.

Type II CTOs were the most commonly identified and had a proximal cap morphology that made it technically easy to cross with the traditional antegrade approach. However, once the distal cap is reached, its antegrade convexity (equal to retrograde concavity) will inevitably deflect any of the available crossing tools toward the subintimal space (and even out of the arterial lumen, which could lead to perforation in extreme cases). Using a planned retrograde tibiopedal access will allow easier crossing of the distal cap's retrograde concavity.

Type III CTOs represent the most challenging type of lesion because the cap morphology will deflect the crossing wire into the subintimal plane when approached in either an antegrade or retrograde direction. Considering this, it is recommended to initially use both antegrade and retrograde accesses, realizing that these cases may take longer than expected and require the use of advanced techniques and reentry devices.

Type IV CTOs were the second most frequent lesion type. Based on cap morphology analysis these lesions are most easily crossed in retrograde fashion since both the proximal and distal caps have retrograde concavity. In type IV, the operator may choose to treat from a pedal approach (ie, TAMI technique) or snare the retrograde crossing wire and deliver therapy from a traditional CFA access.

Limitations

The study represents a single-center experience. The CTO cap analysis was entirely based on angiographic and duplex morphology, and CTOP types were not adjudicated by an independent core laboratory. This analysis did not take into account plaque composition; the presence, number, and quality of collaterals; or the potential presence of other CTO caps located within the hibernating lumen between the visualized proximal and distal caps. If indeed there are multiple CTOs within the space bounded by the identified caps, the risk of subintimal crossing and the necessity to use advanced techniques and/or reentry devices may increase. Popliteal and high retrograde tibial accesses were not utilized in this cohort; therefore, no observations were made in this regard.

Conclusion

The 4 CTO cap types of the CTOP classification system were correlated with the likelihood of crossing these lesions using the traditional antegrade approach. Type I lesions were the easiest to cross in antegrade fashion and type IV the most difficult. Lesion length >10 cm, severe calcification, and CTO types II, III, and IV benefited from the addition of retrograde tibiopedal access. Type IV was the most likely to be crossed in a retrograde fashion from a tibiopedal access.

These findings have potential, important clinical applications that could allow operators to plan an endovascular strategy encompassing access, crossing, and treatment from the beginning of the case. Using a combination of extravascular ultrasound guidance and preplanned retrograde tibiopedal access could translate into time savings, improved efficiency, decreased radiation and contrast use, as well as decreased complications. However, further studies in larger cohorts will be needed to document these purported benefits of applying the CTOP classification to CTO interventions.

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