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Utility of Intra-operative Cone Beam Computed Tomography in Endovascular Treatment of Aorto-iliac Occlusive Disease

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WHAT THIS PAPER ADDS

This study expands the utility of CBCT to the treatment of aorto-iliac occlusive disease. It shows the value of cross sectional imaging intra-operatively, even when conducting gold standard completion angiography together with intra-arterial pressure measurements. This has, to the authors' knowledge, not been investigated before and can be a supplement to other techniques used to improve technical success and patency.

Objective: Endovascular treatment of aorto-iliac occlusive disease (AIOD) is well established, but to maintain long-term patency, secondary interventions are common. Multiple stents and iliac artery tortuosity often make it difficult to evaluate stent compression intra-operatively and this might be a cause for later failure. Completion angiography (CA) and pressure gradient (PG) measurement are often used to assess the final intra-operative result. The purpose of this study was to evaluate the role of intra-operative cone beam computed tomography (CBCT) to optimize the primary operation results.

Method: Fifty-three patients (28 females) were enrolled in a prospective study. All patients underwent endovascular aorto-iliac revascularization. Final intra-operative results were evaluated with additional CBCT, after CA and PG were found to be satisfactory. Imaging findings and imaging based adjunctive procedures were recorded.

Results: One hundred and sixty five stents were placed because of AIOD. Twenty patients underwent adjunctive procedures after the primary stenting. In 24.5% (13/53) cases, adjunctive procedures were indicated solely by the CBCT findings, as both standard CA and PG were normal. Twenty-six of the 53 patients had kissing stents placed at the aortic bifurcation. Of the kissing stent patients, 34.6% required adjunctive procedures and in two thirds these stent compressions were detected only by CBCT.

Conclusion: The use of CBCT revealed a significant number of stent compressions that were not found with CA and PG. When performing endovascular procedures at the aortic bifurcation, CBCT is an excellent intra-operative evaluation method to assess the configuration of deployed stents. In this study, CBCT improved the technical results intra-operatively, which might influence the long-term patency positively.

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INTRODUCTION

Endovascular stenting of aorto-iliac occlusive disease (AIOD) has been shown to be efficient and safe.[1] During mid-term follow up primary patency is decreased, but assisted and secondary patency allow the endovascular technique to be comparable with open aortobifemoral bypass.[2–5]

During endovascular repair, technical success is evaluated by angiography combined with measurement of the pressure gradient across the treated segment. A completion angiogram includes a minimum of two perpendicular views to allow proper evaluation. However, iliac tortuosity, in combination with the frequent use of multiple stents, can make it difficult to properly evaluate the treated aorto-iliac segment. In addition, when AIOD involves the aortic bifurcation, a kissing stent technique is often used and stent compression is virtually undetectable by conventional angiography.[6] Measuring the pressure gradient across a lesion can help to evaluate the result further, but this evaluation can be inadequate, particularly when the distal outflow is compromised.[7]

Optimal stent evaluation is performed using cross sectional imaging but transferring a patient to a standard CT scanner for evaluation is rarely done and often impractical. However, cross sectional imaging can be obtained intra-operatively with cone beam CT (CBCT), which provides a

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low resolution computed tomogram. The CBCT is a rotation of the C-arm while multiple images are taken. The acquired image set is processed in a workstation that allows the operator to evaluate the images in axial, sagittal, and coronal views using multiple reformatting techniques such as multiplanar reconstructions (MPR), maximum intensity projections (MIP) or 3-D rendering intra-operatively.[8] Synonyms of CBCT include 3D rotational angiography or flat panel CT.

The aim of this pilot study was to evaluate the intra-operative utility of CBCT during endovascular AIOD treatment. To the authors' knowledge, no prior study of CBCT use in this setting has been published.

METHOD

The ethical committee at Lund University, Sweden, approved the study and all patients gave oral and written consent prior to the procedure.

Before enrollment all patients underwent pre-operative imaging (MRA or CTA) and clinical evaluation that established arterial occlusive disease in the aorto-iliac segment. Follow up consisted of clinical evaluation, peripheral pulse exam, and ankle brachial index (ABI) at discharge and 1 month post-operatively.

During the study period, October 2012 to May 2014, no patient with AOID was treated by open surgery. After an inadequate response to best medical treatment, endovascular intervention is the primary treatment modality. Lesions are primarily stented, except in younger patients with short lesions who receive PTA alone. This series is not consecutive as CBCT was not available in all angio suites and some of the interventionists were unfamiliar with the technique.

All procedures were performed in angiographic suites with fixed ceiling mounted imaging systems (Artis Zee, Siemens, Germany) using the Care application.[9] Final assessment after endovascular treatment consisted of digital subtraction angiography in two perpendicular projections using 15 mL of contrast (140—200 mgI/mL) with a flow rate of 15 mL/s with the angiographic catheter placed above the aortic bifurcation. In addition, measurement of the arterial pressure proximal and distal to the treated segment was performed pre- and post treatment. The transducer is in a fixed position and is zeroed and the measurements are achieved through the introducer sheath and side hole catheter simultaneously. Angulated completion angiography and pressure measurements are used routinely at the study institution. Residual stenosis $\geq$30% on angiography and mean pressure gradient $>$10 mmHg were considered significant.

The choice of stent was based on type of lesion. Generally, self expandable stents are predominantly used in situations with torturous and angulated vessels and these are routinely post dilated. Balloon expandable stents are routinely used in straight vessels with heavy calcification including the aortic bifurcation or when insufficient results are achieved by self expandable stents. They are positioned inside the cover of the introducer sheath, which is retracted before deployment. Pre-dilation is routinely used in occlusions or when unable to advance the introducer sheath across the lesion. The type of stent used was at the surgeon's discretion.

After completing endovascular treatment and when the completion angiogram showed no significant residual stenosis and no significant pressure gradient was noted across the treated segment, a CBCT (DynaCT, Siemens) was added to the procedure.

CBCT protocol

The detector was positioned in horizontal mode, 30 $\times$ 40 cm, during an 8 second rotation of 200° with a 0.5° angular increment. CBCT contrast enhancement was allowed but not required, except in the presence of renal insufficiency or if the maximum contrast dose threshold had been reached as estimated by OmniVis software (GE Healthcare) based on patients' glomerular filtration rate (GFR).[10] Image post-processing with MPR, MIP, or 3-D was performed at the surgeon's discretion using Inspace software (Siemens, Germany). Additional procedures performed as a result of findings on CBCT were assessed with a second CBCT, with or without contrast. Pressure measurements were also repeated. Stent compression $>$30% was considered significant.

Technical success was defined as absence of significant residual stenosis and pressure gradient. Closure devices were used routinely.

Statistics

All results are presented as mean or median (range). Statistics were done in SPSS version 22 (IBM, Chicago, IL, USA). Wilcoxon Signed Ranks test was performed to calculate statistical differences in pressure gradients and ankle brachial index, before and after treatment. A value of $p < .05$ was considered to be statistically significant. Fischer exact test was used in analysis of stent types and corresponding adjunctive procedures.

RESULTS

Fifty-eight patients were prospectively included. Five patients were excluded from final analysis because of incomplete follow up. The mean age was 67 years (48—82 years) and there were 28 females. The mean body mass index (BMI) was 27 $\pm$ 5 (17—38) and Transatlantic Inter Society Consensus II (TASC II) distribution[11] was: A 51%, B 23%, C 19%, and D 7%. The patients were categorized according to the Rutherford grading scale and the distribution was: mild claudication (2%), moderate claudication (21%), severe claudication (62%), rest pain (13%), and minor tissue loss (2%).

Intra-operative results

All procedures were done under local anesthesia and patients received heparin intra-arterially to achieve an