An Experimental Study to Determine the Optimal Access Route for Renal Artery Interventions

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WHAT THIS PAPER ADDS

At present there are no reports in the literature that specifically define the critical renal artery take-off angle that should be addressed by an antegrade approach. The goal of this study is to design and implement a set of experiments that could empirically determine the critical renal artery take-off angle at which an antegrade approach should be employed rather than a retrograde approach. This study's result will influence clinical practice by providing a surgeon/interventionalist the data required to correctly plan and implement procedures that involve steep renal artery take-off angles.

Objective: The standard approach for endovascular treatment of the renal artery is access via the common femoral artery. However, approximately one in eight patients have a renal artery take-off angle that is less than 50°. In these patients approaching via a femoral access site can be technically challenging. The goal of this study was to design and implement a set of experiments that could empirically determine the critical renal artery take-off angle at which a superior approach would be employed.

Methods: An experimental model of the abdominal aorta, iliac arteries and the renal arteries was constructed using averaged CT angiography data from 10 patients. A number of guide catheter and guide wire combinations were advanced into this model and the force/displacement response was established.

Results: Our results demonstrate that a renal artery take-off angle less than 30° has a reduced probability of achieving stable guide wire placement in comparison with the base 90° anatomy ($p \leq .0001$). Additionally, our results indicate that the probability of achieving stable guide wire access is increased if the stiffness mismatch between the guide catheter and guide wire is minimised.

Conclusions: In conclusion, we recommend a superior approach to the renal artery if the renal artery take-off angle is within the range of 33–38° and a stiff guide wire platform (e.g. an Amplatz stiff) is required to complete the procedure. Finally, we report an equation that can be used to determine the difficulty associated with accessing the renal artery in comparison to the base 90° anatomy.

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INTRODUCTION

The standard approach for endovascular treatment of the renal artery is access via the common femoral artery.[1] In the majority of procedures, the femoral approach will permit delivery and placement of a stable guide wire platform that will allow subsequent treatment. However, approximately one in eight patients have a renal artery take-off angle that is less than 50°.[2] In these patients, an approach via a femoral access site can be technically challenging and may result in an unsuccessful procedure.[3] To overcome this hurdle, a brachial approach has been employed, and has been proven to be safe and feasible within a cohort of patients that have a severe renal artery take-off angle.[4] Moreover, a radial approach has also been shown to be an effective approach for patients with acute aorto-renal angles.[5] However, the value of the renal artery take-off angle at which an operator should switch from an inferior approach to a superior approach is unknown, and currently, procedures are planned on intuition rather than empirical evidence. This inexact feature is also reported within the endovascular textbooks, where the decision to use a superior approach is loosely defined as 'when a steep downward angulation of the renal artery [is present]' or 'when the angle of take-off from the aorta is narrow'.[6,7]

At present, there are no reports in the literature that define the critical renal artery take-off angle that should be addressed by a superior approach. The goal of this study is

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to design and implement a set of experiments that could empirically determine the critical renal artery take-off angle at which a superior approach should be employed rather than an inferior approach.

MATERIALS AND METHODS

An experimental model of the abdominal aorta, iliac arteries and the renal arteries was constructed using CT angiography data from 10 patients; these data were used to determine the average diameters of each vessel and the locations of the ostia. The averaged data were matched with available silicone tube sizes, resulting in a model where the iliac arteries had a diameter of 8 mm, the aorta had a diameter of 25 mm and renal artery diameters were 6.4 mm with an ostium diameter of 9.5 mm. The experimental model was designed to be flexible, in order to vary the angle of the renal artery from 90° (i.e. perpendicular to the aorta) to 60° and to 30°. The silicone model of the vasculature was attached to a Zwick materials testing machine (Zwick Roell, Germany), and filled with water prior to commencement of the series of experiments. The test set-up is illustrated in Fig. 1, where the caption discusses the placement of the wire and guide catheter.

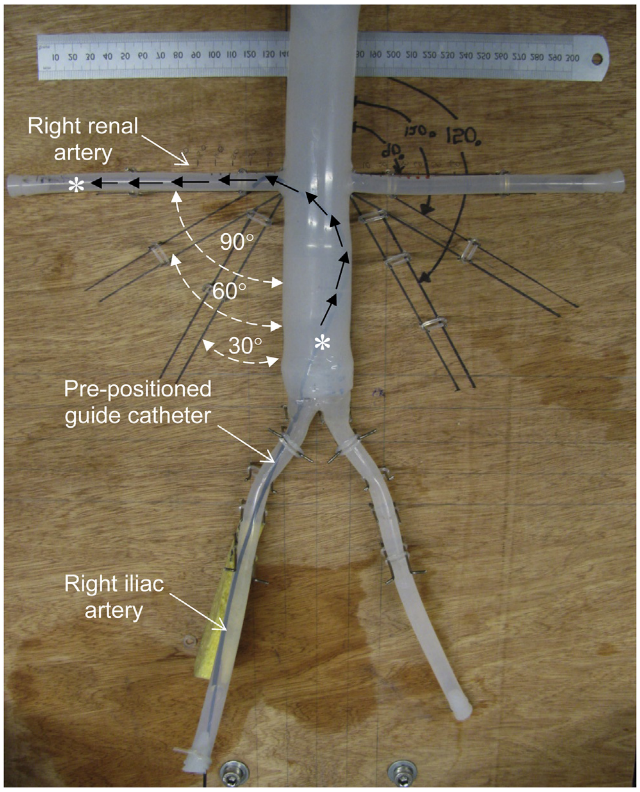

Figure 1. Illustration of the experimental set-up. During the test set-up, a guide catheter is pre-positioned in the model and placed into the renal artery to a depth of 55 mm, a guide wire is then placed in the guide catheter with its tip at the position of the first white star. Subsequent to this, the guide wire is connected to the load cell and advanced along the course of the black arrows to the second white star, during which the advancing force is recorded. The angle of the renal artery can be varied from highlighted positions at 90°, 60° and 30°.

The study was designed to determine the degree of difficulty encountered when establishing a stable guide wire platform within a mock arterial system. Two phases of the intervention were analysed: (i) advancing a ‘soft’ guide-catheter over a static floppy wire, and (ii) advancing a wire through a static guide catheter. In each of these situations, the renal artery take-off angle was varied between 90°, 60° and 30°, and the pre-positioned wire or catheter was placed into the renal artery to a depth of 55 mm. The moveable device was advanced at a constant rate of 300 mm/min. All tests were performed wet. The amount of force required to advance the moveable device was recorded at a rate of 1 data-point per mm. The force recorded was used as the key parameter to ascertain the probability of obtaining and maintaining renal artery access.

The experiments that were conducted in the first phase of the study involved pre-positioning a Radifocus wire (Terumo) within the mock renal artery and subsequently advancing a Glidecath (Terumo) over the wire. The force required to advance the Glidecath over the wire and into the mock renal artery was recorded. The test was repeated five times for each renal artery take-off angle.

The second phase of the study examined a pre-positioned guide catheter within the mock renal artery and advancing a guide wire through the catheter. The guide catheters that were examined included the Glidecath Angled Taper (Terumo); Torcon NB® Advantage KMP (Cook Medical); Beacon® Tip Van Schie2 (Cook Medical); and the Torcon NB® Advantage VS1 (Cook Medical). Each guide catheter was 5 Fr in size. For each pre-positioned guide catheter, a 0.035″ Rosen wire (Cook Medical) and a 0.035″ Amplatz Super Stiff (Boston Scientific) wire was advanced through the catheter and into the mock renal artery. The force required to advance the wire was recorded. The test was repeated five times for each renal artery take-off angle.

For each test, the moveable device was advanced a total distance of 210 mm in three increments of 70 mm, as per the protocol defined by Kenny and McDermott.[8] Results are presented as means and standard deviations, and where statistical significance is presented between two groups this relates to statistical significance testing utilising a Student’s *t*-test.

RESULTS

The results from the first phase of this study indicate that the take-off angle is not a limitation during catheter delivery over a pre-positioned relatively soft wire. In this case, advancement of a Glidecath (Terumo) over the Radifocus wire (Terumo) is achieved with an advancing force that is negligible (<0.25 N) for a range of renal artery take-off angles between 90° and 30°.

In the second phase of the study, two guide wires, Rosen Curved (Cook Medical) and the Amplatz Super Stiff (Boston Scientific), were advanced through four guide catheters for each renal artery take-off angle. The results demonstrate that the advancement of the wire through the mock renal artery is repeatable for each angle/catheter combination.