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Canadian Association of Radiologists Journal xx (2015) 1−6

CANADIAN ASSOCIATION OF RADIOLOGISTS JOURNAL

www.carjonline.org

Vascular and Interventional Radiology / Radiologie vasculaire et radiologie d'intervention

Determination of the Best Parameter for Defining the Hemodynamic Significance of an Iliac Artery Stenosis Detected on Computed Tomography Angiography

Nick Lougheed, MD, FRCPC, Jeff Jaskolka, MD, FRCPC*, Rob Beecroft, MD, FRCPC, Ravi Menezes, PhD

Joint Department of Medical Imaging, University Health Network, Toronto General Hospital, Toronto, Ontario, Canada

Abstract

Purpose: The purpose of this study was to determine the best parameter, derived from computed tomography angiography (CTA) for accurate prediction of a hemodynamically significant stenosis of the common or external iliac artery.

Methods: A retrospective keyword search was performed on the Radiology Information System at our tertiary academic medical centre. Reports from January 2008 to September 2013 were searched using the keywords *iliac*, *stenosis*, and *pressure*. Patients who had both and CTA and a pelvic angiogram with pressure measurements obtained across a potential stenosis were selected. Using 3D postprocessing software (TeraRecon, Foster City, CA, USA), the CTAs were analysed for the following parameters of each lesion: minimum diameter of stenosis, minimum cross-sectional area of stenosis, percent narrowing of vessel diameter, and percent reduction in vessel area. The percent stenosis was calculated in reference to the outer diameter at the point of maximal narrowing and also in reference to a normal segment of vessel more distal to the stenosis. These parameters were then compared with the measured pressure gradient using receiver-operating characteristic analysis and the Mann-Whitney *U* test to determine which best predicted a significant stenosis, defined as a greater than 10% drop in systolic pressure across a lesion.

Results: One hundred and two stenoses in 83 patients (26 women, 57 men; 47-88 years old) were identified. Mean diameter of the stenosis was 2.8 mm for significant stenosis compared to 3.8 mm in nonsignificant stenoses ($P = .005$). Mean minimum area for significant stenoses was 11.8 mm^2 compared to 17.22 mm^2 for nonsignificant stenoses ($P = .032$) No other variables showed a significant difference between significant and nonsignificant stenoses. A minimum diameter of $\leq$4.0 mm at the level of a stenosis is 92% sensitive and 48% specific for predicting a hemodynamically significant iliac artery stenosis, with a positive predictive value of 88%.

Conclusions: A simple measurement of the minimum diameter of an iliac artery at the level of stenosis is the best predictor of the hemodynamic significance of a stenosis in the common or external iliac artery.

Résumé

Objet : L'étude visait à déterminer le paramètre le plus précis pour prédire une sténose de l'artère iliaque commune ou externe importante sur le plan hémodynamique à partir d'une angiographie par tomodensitométrie (ATDM).

Méthodes : Nous avons réalisé une recherche rétrospective par mots clés (*iliac*, *stenosis* et *pressure*) dans le système d'information radiologique de notre centre universitaire de soins tertiaires. Notre recherche portait sur des rapports ayant été produits entre janvier 2008 et septembre 2013. Nous avons sélectionné les patients qui ont subi une ATDM et une angiographie pelvienne avec mesure de la pression au niveau de la sténose présumée. Les ATDM ont ensuite été analysées au moyen d'un logiciel de post-traitement permettant les reconstructions tridimensionnelles (TeraRecon, Foster City, Californie, États-Unis). Les paramètres suivants ont été mesurés pour chaque lésion: diamètre minimal de la sténose, section transversale minimale de la sténose, pourcentage de rétrécissement du diamètre du vaisseau et pourcentage de réduction de la section du vaisseau. Le pourcentage de sténose a été calculé en fonction du diamètre externe au point de rétrécissement le plus marqué et d'un segment normal du vaisseau situé en distal de la sténose. Nous avons ensuite réalisé une analyse de la fonction d'efficacité de

* Address for correspondence: Jeff Jaskolka, MD, FRCPC, Joint Department of Medical Imaging, University Health Network, Toronto General Hospital, 200 Elizabeth St, Toronto, Ontario M5G 2C4, Canada.

E-mail address: jjaskolka@mtsinai.on.ca (J. Jaskolka).

http://dx.doi.org/10.1016/j.carj.2015.09.005

l'observateur et un test U de Mann-Whitney dans le but de comparer ces paramètres aux gradients de pression mesurés et de déterminer celui qui était le plus susceptible de prédire une sténose importante (définie comme une chute de plus de 10 % de la pression systolique dans la lésion).

Résultats : Nous avons relevé 102 sténoses chez 83 patients (26 femmes et 57 hommes âgés de 47 à 88 ans). Le diamètre moyen était de 2,8 mm pour les sténoses importantes, contre 3,8 mm pour les sténoses non importantes ($P = 0{,}005$). La section minimale moyenne variait également: 11,8 mm^2 pour les sténoses importantes, contre 17,22 mm^2 pour les sténoses non importantes ($P = 0{,}032$). Aucune autre variable n'a présenté de différence notable selon qu'il s'agissait d'une sténose importante ou non. Comme méthode de prédiction d'une sténose de l'artère iliaque importante sur le plan hémodynamique, un diamètre minimal égal ou inférieur à 4,0 mm au niveau de la sténose offrait une sensibilité de 92 %, une spécificité de 48 % et une valeur prédictive positive de 88 %.

Conclusion : La simple mesure du diamètre minimal de l'artère iliaque au niveau de la sténose constitue le facteur prédictif le plus précis de l'importance hémodynamique d'une sténose de l'artère iliaque commune ou externe.

Key Words: Computed tomography angiography; Iliac artery; Peripheral vascular disease; Stenosis; Vascular imaging

Computed tomography angiography (CTA) is commonly used in the evaluation of patients with peripheral vascular disease presenting with symptomatic claudication. It has largely replaced digital subtraction angiography (DSA) in the diagnosis of peripheral arterial disease [1]. Along with diagnosis, CTA provides additional information for treatment planning regarding stenosis length, distribution and severity. It also allows for treatment planning, including measurement vessel size which aids in choice of angioplasty balloons and stents prior to DSA and endovascular intervention. In current practice, CTA has replaced DSA as the diagnostic test of choice in peripheral vascular disease [2].

CTA is known to be comparable to digital subtraction angiography (DSA) for anatomic assessment of the severity of stenosis in the iliac arteries [3]. When compared to DSA as the gold standard; sensitivity, specificity, and accuracy of CTA for the detection of significant (>50%) stenosis and occlusion of aortoiliac arteries are 92%, 93%, and 95%, respectively [4]. Most research evaluating performance of CTA focuses on direct anatomic comparison to DSA. Although many articles report similar sensitivity and specificity for CTA in detecting stenosis, no article to date comments on the best measurement parameters for prediction of hemodynamic significance of stenosis. Furthermore, there is no research to date which uses CTA findings to predict the hemodynamic significance of a stenosis based on the true gold standard, a directly measured pressure gradient, which is proportional to the flow across the stenosis [5].

Established parameters exist using North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria for measuring carotid stenosis on CTA [6]. Using these parameters, research has shown moderate correlation between percent stenosis measured on CTA, with hemodynamic parameters measured with Doppler ultrasound [7]. No such system for predicting hemodynamic significance of iliac arteries exists.

The purpose of this study is to determine the best parameter, derived from CTA for accurate prediction of a hemodynamically significant stenosis of the common or external iliac artery.

Materials and Methods

Institutional research ethics board approval was obtained. A retrospective keyword search was performed on the Radiology Information System at our tertiary academic medical centre. Reports from January 2003 to September 2013 were searched using the keywords *iliac*, *stenosis*, and *pressure*. Patients who had symptomatic peripheral vascular disease and a CTA of the abdomen and pelvis within 1 month prior to pelvic DSA with pressure measurements obtained across a potential stenosis were selected. Patients with complete occlusions and prior stenting of the iliac arteries were excluded.

Using 3D postprocessing software (TeraRecon, Foster City, CA, USA), the CTAs were analysed. The following measurements were obtained at the level of stenosis: minimum lumen diameter, maximum vessel diameter, and minimum lumen cross-sectional area. In a corresponding adjacent segment of normal iliac artery (common or external), the following measurements were obtained: maximum outer diameter, cross sectional area (Figure 1). In cases where the iliac artery was diffusely diseased, the most normal segment of adjacent iliac artery was assessed and the measurements were extrapolated to what was most likely to be the size of the normal vessel (Figure 2).

Percent stenosis was calculated in 3 ways. First, the percentage was obtained using the measurements taken at the level of stenosis. Second, the percentage was obtained using adjacent normal artery as the outer diameter. This method is comparable to NASCET style for measuring carotid stenosis [8]. Third, the percentage was calculated using a comparison of cross-sectional area at the level of stenosis to adjacent normal iliac artery. For each type of calculation a 50% and 70% cutoff were used as anatomic criteria for stenosis. The minimum lumen diameter was also assessed to determine if a suitable cut off value for hemodynamic significance could be identified.

The measurements obtained on CTA were compared to pressure measurements obtained across the presumed stenosis during DSA. Hemodynamic significance of a stenosis