From the Society for Vascular Surgery

The contemporary management of renal artery aneurysms

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Background: **Renal artery aneurysms (RAAs) are rare, with little known about their natural history and growth rate or their optimal management. The specific objectives of this study were to (1) define the clinical features of RAAs, including the precise growth rate and risk of rupture, (2) examine the current management and outcomes of RAA treatment using existing guidelines, and (3) examine the appropriateness of current criteria for repair of asymptomatic RAAs.**

Methods: **A standardized, multi-institutional approach was used to evaluate patients with RAAs at institutions from all regions of the United States. Patient demographics, aneurysm characteristics, aneurysm imaging, conservative and operative management, postoperative complications, and follow-up data were collected.**

Results: **A total of 865 RAAs in 760 patients were identified at 16 institutions. Of these, 75% were asymptomatic; symptomatic patients had difficult-to-control hypertension (10%), flank pain (6%), hematuria (4%), and abdominal pain (2%). The RAAs had a mean maximum diameter of 1.5 ± 0.1 cm. Most were unilateral (96%), on the right side (61%), saccular (87%), and calcified (56%). Elective repair was performed in 213 patients with 241 RAAs, usually for symptoms or size >2 cm; the remaining 547 patients with 624 RAAs were observed. Major operative complications occurred in 10%, including multisystem organ failure, myocardial infarction, and renal failure requiring dialysis. RAA repair for difficult-to-control hypertension cured 32% of patients and improved it in 26%. Three patients had ruptured RAA; all were transferred from other hospitals and underwent emergency repair, with no deaths. Conservatively treated patients were monitored for a mean of 49 months, with no acute complications. Aneurysm growth rate was 0.086 cm/y, with no difference between calcified and noncalcified aneurysms.**

Conclusions: **This large, contemporary, multi-institutional study demonstrated that asymptomatic RAAs rarely rupture (even when >2 cm), growth rate is 0.086 ± 0.08 cm/y, and calcification does not protect against enlargement. RAA open repair is associated with significant minor morbidity, but rarely a major morbidity or mortality. Aneurysm repair cured or improved hypertension in >50% of patients whose RAA was identified during the workup for difficult-to-control hypertension. (J Vasc Surg 2015;61:978-84.)**

Renal artery aneurysms (RAAs) are rare, with an estimated incidence of 0.09% in the general population.[1] Although uncommon, clinicians are more frequently encountering RAA due to the increased use of cross-sectional magnetic resonance and computed tomography (CT) imaging to evaluate other diseases.[1-3] Currently accepted indications for RAA repair include symptoms, size >2 cm, and aneurysms in women of childbearing age. These criteria are based on studies conducted before the widespread use of cross-sectional imaging.[1-6] Thus, there remains significant controversy surrounding RAA treatment criteria because the incidence, risk of rupture, and growth rate have not been determined.[4]

A contemporary single-institution study recently addressed issues of RAA growth rate and risk of rupture, based on aneurysm size, but the conclusions of the study were limited by small numbers.[7] Consequently, this multi-institutional study was conducted to (1) define the clinical features of RAA, including the precise growth rate and risk of rupture, (2) examine the current management and outcomes of RAA treatment using the existing guidelines, and (3) examine the appropriateness of current criteria for repair of asymptomatic RAA.

METHODS

Inclusion criteria and patient identification. RAAs were defined as focal, isolated dilatation of all three layers of the arterial wall that measured >1.5 times the diameter of the disease-free proximal adjacent arterial segment.[8] Patients with pararenal or juxtarenal aortic aneurysms and proximal RAAs that originated from an aortic aneurysm were excluded.

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Author conflict of interest: none.

Presented at the Plenary Session of the 2014 Vascular Annual Meeting of the Society for Vascular Surgery, Boston, Mass, June 4-7, 2014.

Additional material for this article may be found online at www.jvascsurg.org.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2014.10.107

Patients were identified using International Classification of Diseases, Ninth Revision codes 442.1 (aneurysm of renal artery) and 442.89 (aneurysms of other specific artery) using physician, hospital, and radiology billing records. Principal investigators at each institution were responsible for ensuring inclusion of all patients at their institution. Symptomatic RAAs were defined by using previously published criteria, including flank pain, abdominal pain, hematuria, and difficult-to-control hypertension. Symptoms were attributed to the aneurysm if no other etiology was discovered or if the symptoms resolved after surgery, or both. The principal investigator from each institution was responsible for reviewing the primary aneurysm images and the reports for each patient and confirming size and growth data.

Database management. This multi-institutional study examined all patients presenting with RAAs between 2003 and 2013 at each hospital, including patient transfers. Pseudotraumatic, mycotic, and post-traumatic aneurysms were excluded. Primary end points included (1) morbidity and mortality of conservative management, (2) morbidity and mortality of repair, (3) freedom from acute complications and emergency repair (rupture), and (4) patient survival.

After Investigational Review Board approval, data were collected, deidentified, and stored in a password-encrypted central database managed by the Vascular Low-Frequency Consortium at the University of California, Los Angeles. Patient consent was not required by the Investigational Review Board due to the study's minimal risk and retrospective nature. Patient data from each institution were examined for accuracy and completeness by the consortia coordinators, and incomplete entries were corrected. Collective data were reviewed, critiqued, and modified by all study participants.

Statistics. Data were maintained in an Excel 14 database (Microsoft Corp, Redmond, Wash). Statistical analysis was performed using SPSS 20 software (IBM Corp, Armonk, NY). Continuous variables are presented as mean ± standard deviation, unless noted otherwise. Differences between subgroups were analyzed using independent Student *t*-test, Kruskal-Wallis test, Mann-Whitney *U* test, and analysis of variance. Differences between subgroups of noncontinuous variables were analyzed using the χ^2 test or Fisher exact test. Multivariable analysis was performed using binary and multinomial logistic regression. Cochran and Mantel-Haenszel methods were used to derive hazard ratios and 95% confidence intervals. All time-dependent variables were analyzed using Kaplan-Meier life tables. The maximum diameter for each aneurysm was determined using the same imaging modality in sequential imaging studies to reduce variability, and growth rate was determined using a weighted average. A *P* value of <.05 was considered significant.

RESULTS

Patient demographics and comorbidities. We identified 760 patients with 865 RAAs at 16 institutions from hospitals in different regions of North America (Supplementary Table, online only). The mean age at diagnosis was 61 ± 13 years (range, 12-99 years), and RAAs occurred predominantly in women (M:F = 1:2). Comorbidities (Table I) included hypertension (82%), with a mean blood pressure of 157/86 mm Hg (on a mean of two antihypertensive medications). Unlike patients with degenerative aneurysms, only 21% had a history of tobacco use. Concomitant extra-RAAs occurred in 14% of patients, the most common sites being the abdominal aorta and splenic artery.

Table I. Patient comorbidities and concomitant extrarenal aneurysms

Variables	*Patients (N = 760), No. (%)*
Comorbidities	
Hypertension	623 (82)
Hypercholesterolemia	190 (25)
Smoking	160 (21)
Diabetes mellitus	122 (16)
Coronary artery disease	76 (10)
Chronic obstructive pulmonary disease	30 (4)
Connective tissue disorder[a]	15 (2)
Extrarenal aneurysms	
Abdominal aorta	37 (5)
Splenic artery	23 (3)
Thoracic aorta	13 (2)
Iliac artery	12 (2)
Celiac artery	5 (1)
Hepatic artery	4 (1)

[a]Ehlers-Danlos syndrome, Marfan syndrome.

Table II. Presenting symptoms

Symptoms	*Patients (N = 760), No. (%)*
Asymptomatic	569 (75)
Difficult-to-control hypertension	76 (10)
Flank pain	46 (6)
Hematuria	30 (4)
Abdominal pain	15 (2)
Other (back pain, etc)	24 (3)

Most patients were asymptomatic, with the aneurysm discovered incidentally, and 25% presented with symptoms (Table II). No patient presented to a participant site with rupture; however, three patients with ruptured RAAs were transferred, after rupture, to institutions involved in this study.

Imaging and diagnosis. CT angiography was the most frequently used imaging modality for the RAA diagnosis (58%), CT (without contrast) was the next most frequent (24%), followed by magnetic resonance angiography (6%), catheter angiography (5%), and ultrasound imaging (4%).

Aneurysm characteristics. The distribution and location of RAAs are shown in Fig 1, with 61% located on the right side. The aneurysm most commonly originated in the