

Routine Ultrasound Screening for Abdominal Aortic Aneurysm among 65- and 75-Year-Old Men in a City of 200,000 Inhabitants

César Vazquez, MD, Natzi Sakalihan, MD, Jean-Bernard D'Harcour, MD, and Raymond Limet, MD, Liege, Belgium

Unruptured abdominal aortic aneurysm (AAA) is seldom recognized. Thus it is difficult to know whether the incidence of AAA in the general population is high enough to warrant routine screening at least in men after a certain age. Ultrasound screening studies to evaluate the incidence of AAA have been carried out in several English-speaking and Scandinavian countries. The purpose of this report is to describe the results of a study carried out in Belgium. All 65- and 75-year-old men living in the city of Liege, Belgium, were given the opportunity to undergo a free ultrasound examination. Only 41% of the target population was examined. AAA defined as abdominal aortic diameter of >30 mm was observed in 28 subjects (incidence: 3.8%). Mean abdominal aortic diameter was 34.7 mm. A diameter >29 mm was observed in 33 subjects (incidence 4.5%). Mean abdominal aortic diameter was 30.4 mm. On the basis of epidemiological data collected, a high-risk population for AAA was identified. Arterial hypertension ($p < 0.05$), previous coronary artery surgery ($p < 0.05$), and smoking ($p < 0.06$) were more common in subjects with than without AAA. The overall cost of screening was \$18,175. The cost per AAA diagnosed was \$551.00. (*Ann Vasc Surg* 1998;12:544-549.)

INTRODUCTION

In the United States, ruptured abdominal aortic aneurysm (AAA) accounts for 1.2% of mortality among men over 65 years of age and 0.6% among women in the same age group.^{1,2} In England and Wales in 1983, ruptured AAA was the cause of 1.9% of deaths among males and 0.7% among females over 65 years.³ In The Netherlands in 1990,

the incidence of fatal ruptured AAA was 1.4% for men and 0.5% for women over the age of 55 years.⁴

Nearly 40% of patients presenting ruptured AAA die before admission to the hospital.⁵ Operative mortality ranges from 40 to 50%.^{1,5,7} According to Ingoldby et al.,⁷ overall mortality due to ruptured AAA is 80.2%. This contrasts starkly with the operative mortality of elective surgery for unruptured AAA which, thanks to progress in surgical techniques, is <3%.^{1,8}

Although a significant number of patients are still treated after rupture, the number of elective procedures for AAA has risen over the last 30 years. This is probably due not only to longer life expectancy and improvement in diagnostic techniques but also to an increasing incidence of AAA in both men and women as reported in several studies.^{4,9-11}

From the Departments of Cardiovascular Surgery and Medical Imaging, Sart-Tilman University Hospital Center, Liege, Belgium.

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Correspondence to: R. Limet, MD, Cardiovascular Surgery Department, Sart-Tilman University Hospital Center, (B35) 4000 Liege, Belgium.

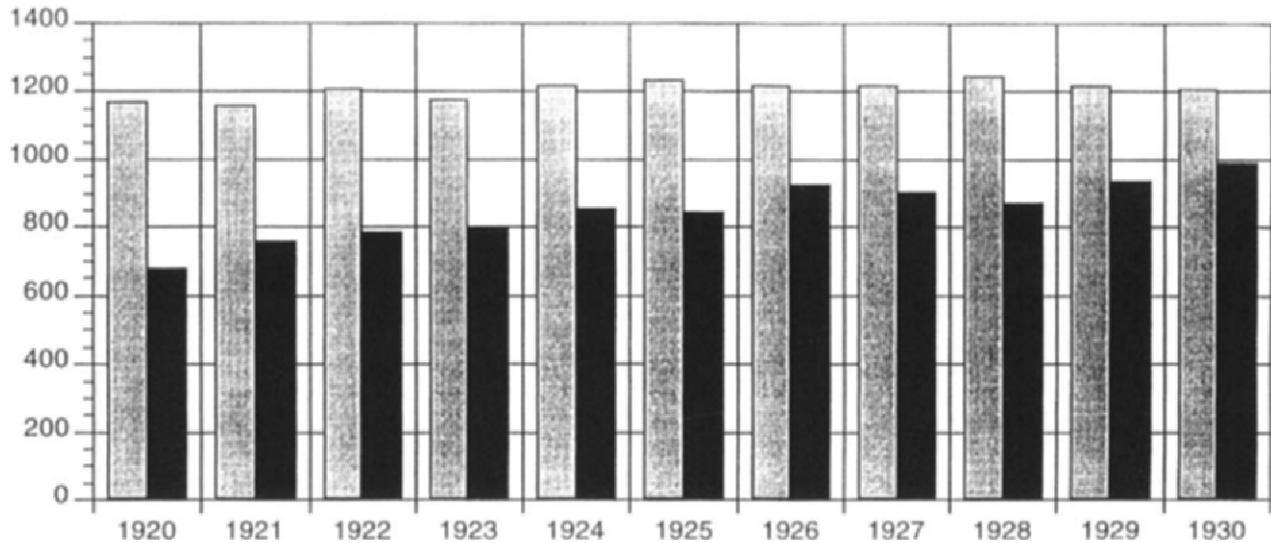


Fig. 1. Birth statistics for the city of Liege between 1920 and 1930. A total of 9344 men and 13,270 women were born during that period, with 729 men born in 1920 and 1035 men born in 1930. Black bars, men; shaded bars, women.

Care costs are two- to three-fold higher for patients treated after rupture than for patients treated electively.^{2,12}

The purpose of this study was to evaluate the incidence of AAA in a city with an estimated population over 200,000 and identify a population at risk. For this purpose, we carried out routine ultrasound screening and collected epidemiological data in 65- and 75-year-old males living in Liege, Belgium. This study was funded by the French-speaking Belgian community.

MATERIAL AND METHODS

This study was undertaken with the approval by the Board of the Physicians' Association and the Ethics Committee of the University Hospital of Liege. Between December 14, 1995 and November 24, 1996, a personalized letter offering the opportunity to undergo free ultrasound screening for AAA was sent to 1764 men born in 1920 ($n = 729$) and 1930 ($n = 1035$). Selection was based on birth records for the city of Liege, Belgium (Fig. 1).

Before ultrasound procedure, each subject responded to a physician-administered epidemiological survey concerning risk factors for cardiovascular disease (hypertension, diabetes, hypercholesterolemia, smoking), previous cardiovascular events (angina, myocardial infarction, stroke, transient ischemic attacks), ongoing medical treatment, previous cardiovascular surgery (aortic, cardiac, or pe-

ripheral vascular surgery), and family history of AAA (documented AAA treated surgically, documented AAA not treated surgically, sudden death). Sketchy, unreliable responses were not taken into account.

Ultrasound examinations were performed by a radiologist and surgeon from the Medical Imaging and Cardiovascular Departments of the University Hospital Center of Sart-Tilman in Liege, Belgium. The devices used were a Toshiba Sonolayer SSH/140A (3.75 MHz transducer) between December 14, 1995 and June 30, 1996, and a Siemens Sonoline Elegra (3.5 MHz transducer) between September 14, 1996 and November 24, 1996. Both anteroposterior diameter (external edge of the aortic wall) and transverse diameter of the infrarenal aorta and the iliac bifurcation were measured. Infrarenal abdominal aortic diameter was considered normal up to 29 mm.^{9,13} Collaterally AAA was defined as an anteroposterior abdominal aortic diameter >29 mm. Statistical analysis was performed using an SAS system.

RESULTS

Of the 1764 subjects to whom letters offering the opportunity of undergoing AAA screening were sent, a total of 727 (41%) consented. Of these 727 subjects, 465 were born in 1930 (64%) and 262 in 1920 (36%). Ultrasound was feasible in 98.5% of cases. Ultrasound failed in 11 cases because of obe-

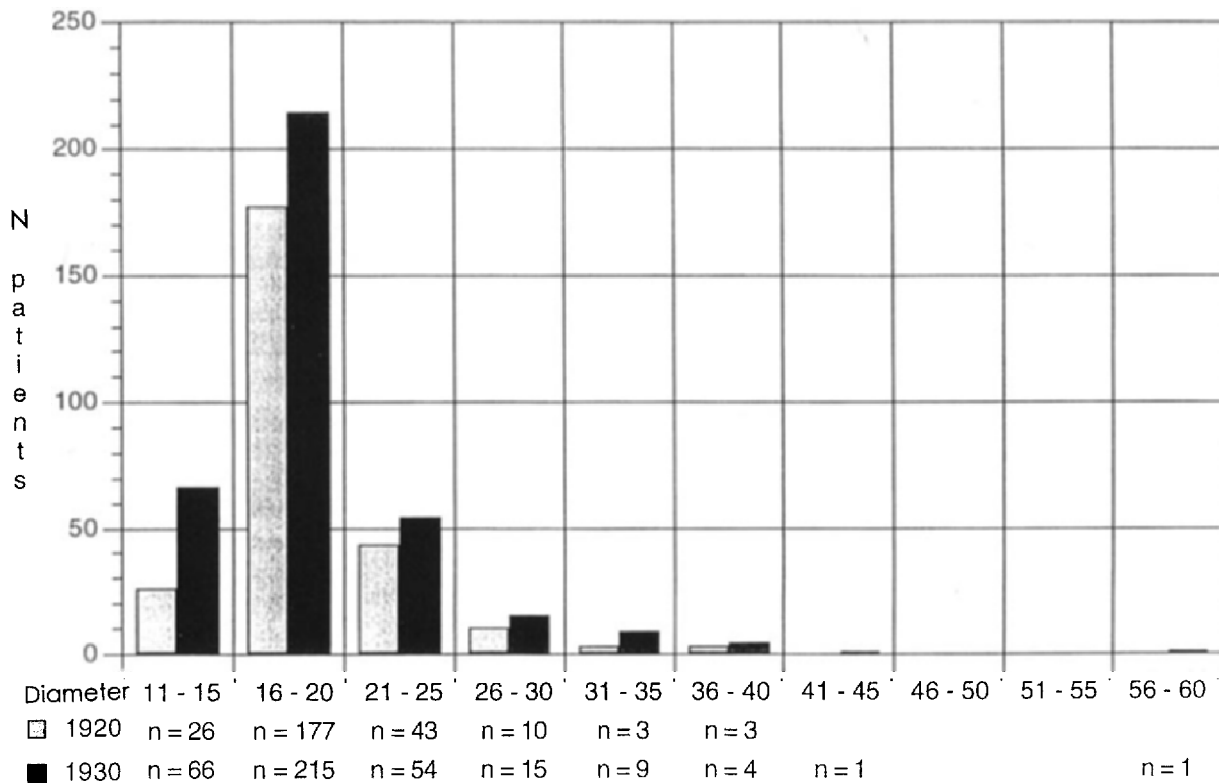


Fig. 2. Infrarenal abdominal aortic diameter in function of age.

sity ($n = 5$), sequelae of previous surgery ($n = 2$), and air artifacts ($n = 4$). Findings in failed cases were classified normal.

The mean anteroposterior diameter of the infrarenal abdominal aorta for the 727 subjects examined was 18.9 mm (range: 11.5-60 mm). Mean anteroposterior diameter was 18.9 mm for the 465 subjects born in 1930 vs. 19.2 for the 262 subjects born in 1920 (Fig. 2). Overall, the mode was 17 mm and the median was 18 mm.

Anteroposterior diameter was >29 mm in 33 subjects including 21 born in 1930 (4.5%) and 12 born in 1920 (4.6%). In these 33 patients, the mean anteroposterior of the infrarenal abdominal aorta was 30.9 mm, i.e., 31.2 mm for subjects born in 1930 and 30.3 for subjects born in 1920. The incidence of AAA defined as anteroposterior diameter >29 mm was 4.5%.

Twenty-eight subjects presented an abdominal aortic diameter >30 mm, including 18 (3.9%) born in 1930 and 10 (3.8%) born in 1920. The mean anteroposterior diameter of the infrarenal aorta in these 28 patients was 34.7 mm, i.e., 35.6 mm for subjects born in 1930 vs. 33.9 mm for subjects born in 1920. The incidence of AAA defined as anteroposterior diameter >30 mm was 3.8%.

Risk factors for cardiovascular disease are listed in Table I. Hypertension was noted in 204 subjects (28.1%), dyslipidemia in 185 subjects (25.4%), smoking in 163 subjects (22.4%), and diabetes in 85 subjects (11.6%). Table I also indicates risk factors for cardiovascular disease in subjects without ($n = 694$) and with ($n = 38$) AAA. The only statistically significant difference between the two populations was for hypertension ($p < 0.05$). The difference for smoking was nearly significant ($p < 0.06$).

Table II shows data regarding previous cardiovascular surgery. A total of 72 subjects had undergone previous cardiovascular surgery. The procedure was coronary artery bypass grafting (CABG) in 44 subjects (6.2%), aortic surgery in 13 (1.2%) (AAA repair in 5 cases and aortobifemoral bypass grafting in 8 cases), and peripheral vascular surgery (PVS) in 15 (2.1%). Table II also indicates previous surgery for cardiovascular disease in subjects without ($n = 694$) and with ($n = 38$) AAA. The only statistically significant difference between the two populations was for CABG ($p < 0.01$).

Data collected regarding medical treatment and family history of AAA were considered too sketchy and unreliable for meaningful analysis.

The cost of each screening examination for AAA

Table I. Risk factors for cardiovascular disease in the study population ($n = 727$) without ($n = 694$) or with ($n = 33$) AAA

	Without AAA		With AAA		<i>p</i>
	<i>n</i>	%	<i>n</i>	%	
Dyslipidemia	172	24.92	13	35.13	NS
Diabetes	78	11.30	7	18.91	NS
Hypertension	188	27.24	17	45.94	<0.05
Smoking	156	21.73	13	35.13	<0.06

NS, nonsignificant.

Table II. Incidence of previous cardiovascular surgery in the overall population, subjects without AAA, and subjects with AAA

	Aortic surgery	Coronary artery bypass	Peripheral vascular surgery
Overall population ($n = 727$)	13(1.78%)	44(6.05%)	16(2.18%)
Subjects with AAA ($n = 33$)	1(3.03%)	6(18.1%)	2(6.06%)
Subjects without AAA ($n = 694$)	12(1.77%)	38(5.48%)	14(1.87%)

The difference between the two subgroups was not significant for aortic surgery or peripheral vascular surgery. The difference was significant for coronary artery bypass ($p < 0.01$).

was calculated on the basis the officially established rate for ultrasound study: \$25.00/procedure. Thus the overall cost of screening was \$18,175 (875×727). The cost of diagnosis of each AAA was \$551.00, calculated by dividing the overall cost by the number of AAA discovered ($\$551.00/33$ AAA).

DISCUSSION

The reliability of population-based studies depends on compliance. The percent of compliance in previous AAA screening studies in English-speaking and Scandinavian countries has ranged from 51 to 81%.^{9,14} At only 41.1%, compliance in our study can be considered too low to allow comparison. Low compliance was probably due to differences in attitude not only of the general public but also of physicians (suspicion of private practitioners screening efforts outside their control, lack of motivation, and more undisciplined Latin mentality). Lower compliance by 75-year-olds than 65-year-olds was probably due to more limited mobility of

the older group. In comparison, compliance rates observed in different sections of Liege, Belgium during a breast cancer screening program carried out between 1992 and 1995 ranged from 18 to 43.6% but it should be noted that the target population was younger and that a mobile unit was used, thus making participation more convenient.¹⁵

Ultrasound is considered the method of choice for AAA screening.^{9,14} In addition to being feasible in 98.5% of cases, the sensitivity of ultrasound is over 95% and its specificity is 100%. Other advantages of ultrasound include noninvasiveness, good reproducibility, and cost-effectiveness (seven-fold less expensive than an abdominal CT scan). However, Ellis et al.¹² reported that ultrasound underestimates aortic aneurysm diameter in comparison with the CT scan, particularly if transverse diameter rather than anteroposterior diameter and/or the suprarenal rather than the infrarenal aorta are studied. Yucel et al.¹⁶ stated that differences between anteroposterior measurements made by ultrasound and CT scan must be >4 to 5 mm to be significant. Grimshaw and Docker¹⁷ emphasized that standard deviation between measurements obtained in two ultrasound examinations by the same operator should not exceed ± 1.3 mm. In an experimental study carried out by Comstock et al.,¹⁸ the mean difference in measurements obtained by two operators was 2.1 mm for anteroposterior diameter and 3.1 mm for transverse diameter. Similarly, Akkersdijk et al.¹⁴ reported that the standard deviation between measurements obtained by different operators was 2.2 mm for anteroposterior diameter and 5.3 mm for transverse diameter. In the present study, we considered only anteroposterior diameter.

Setting strict criteria for defining AAA is difficult since the diameter of the aorta varies according to several factors such as sex, age, and body surface. Various diameters have been used for diagnosis of AAA in previous ultrasound studies. McGregor et al.¹⁹ proposed an infrarenal aorta diameter >30 mm. In a pilot study including 550 men between the ages of 65 and 75 years, Smith et al.¹³ proposed an infrarenal diameter of 29 mm because it was three standard deviations greater than the mean diameter of 21 mm. This definition has the advantage of being based on statistical data obtained in a relatively homogeneous, controlled population. The Ad Hoc Committee of the ISCS/SVS²⁰ defines AAA as an infrarenal diameter $>150\%$ of "normal." However, this definition is difficult to use in screening studies as mean diameters must be calculated in function of age, sex, and body surface. Had we used the Ad Hoc Committee definition for our study in

Table III. Data from previous screening studies for AAA

Reference	Compliance (%)	Number of subjects	Age (years)	Incidence of AAA ^a (%)
15	58.8	4,237	65-80	4.3
13	76.3	2,664	65-75	8.4
3	51.7	497	65-74	4.2
9	75.0	364	74	8.5
This study	41.0	727	65 and 75	4.53

^aDefined as maximum transverse diameter >29 mm.

which mean diameter was 17 mm, the cutoff point between normal and aneurysmal would have been 25.5 mm and the incidence of AAA would have been 5.22% (38 cases).

In the present study, we targeted 65- and 75-year-old men for routine ultrasound screening for AAA. The highest incidence of AAA is in subjects over 80 years, the optimal effect on mortality in function of age at diagnosis is observed between 70 and 75 years, and the lowest operative mortality is observed between the ages of 55 and 65 years. Thus, since the detection rate is lower and the cost of screening per case diagnosed is higher^{13,21} in these cases, the best age group for screening in terms of cost effectiveness is that between 65 and 75 years.^{9,13,21} In the city of Liege, there are 9344 men between the ages of 65 and 75 years. We chose to study 65-year-olds (born in 1930) and 75-year-olds (born in 1920) to obtain an easily useable sample for statistical analysis.

According to the Ad Hoc Committee of the ISCS/SVS,²⁰ mean infrarenal abdominal aortic diameter measured by ultrasound ranges from 14.1 to 20.5 mm (margin of error 0.04 to 0.37). Sonesson et al.²² studied infrarenal aortic diameter in function of age, sex, and body surface in healthy subjects and reported a diameter of 15.7 ± 1.5 mm for the 61.4 ± 3.6 year age group and 17.3 ± 2 mm for the 68.6 ± 2.7 year age group. In our study, mean aortic diameter was 18.9 (range: 11.5 to 60 mm) and the mode was 17 mm. Anteroposterior aortic diameter >30 mm was observed in 28 male subjects (mean diameter: 34.7 mm) and the incidence of AAA was 3.8%. Anteroposterior aortic diameter >29 mm was observed in 33 cases (mean diameter: 30.9 mm) and the incidence of AAA was 4.5%. This incidence of AAA is comparable with previous reports^{3,9,13,14} (Table III).

On the basis of epidemiological data obtained, we attempted to define a high-risk population for AAA. The incidence of hypertension was 45.9% in

the AAA Group as compared with 27.2% in the general population ($p < 0.05$) and the incidence of smoking was 35.1% in the AAA group as compared with 21.7% in the general population ($p < 0.06$). The higher incidence of CABG [18.1% in the AAA group versus 5.5% in the general population ($p < 0.01$)] could be the result of a bias as patients who have undergone previous surgery may be more aware of the risks of cardiovascular disease and thus more likely to take part in screening.

The effectiveness of screening studies could be enhanced by specific targeting of high-risk groups. The incidence of AAA in subjects over the age of 65 with hypertension was 12% in the study of Allen et al.²³ and 9% in the study of Lederle et al.²⁴ In our department, screening for AAA was carried out on 110 patients scheduled to undergo surgery for either coronary artery disease ($n = 72$) or peripheral vascular disease ($n = 38$). The incidence of AAA was 9.7% in patients with coronary artery disease and 2.6% in patients with peripheral vascular disease.^{25,26} In a group of patients who underwent coronary artery surgery between the ages 34 and 77 years, Nevelsteen et al.²⁷ reported that the incidence of AAA was 8.8%. In a study of patients with peripheral vascular disease between the ages of 31 and 83 years, Shapira et al.²⁸ observed that the incidence of AAA was 4.6%. In a group of male patients with peripheral arteriopathy, Allardice et al.²⁹ reported that the incidence of AAA was 17%.

CONCLUSION

Estimates of the incidence of AAA in the general population vary. In our series of 65- and 75-year-old men, the incidence of AAA was 4.5%. Although surgical treatment of all these AAA may not be required, surveillance is necessary. The only way to reduce the 80% mortality rate observed after ruptured AAA (80%) is to perform elective surgical repair before rupture. To increase the number of elective procedures, routine screening is necessary using a more reliable technique than simple palpation of the abdomen. The results of this study demonstrate that ultrasound is a cost-effective method for routine ultrasound screening in 65- and 75-year-old men. The efficacy of routine screening could be further improved by targeting a subgroup at risk. In this regard, the present study showed that subjects with hypertension, a history of coronary artery bypass, and smoking constitute a high-risk population for AAA.

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