Office-based ultrasound screening for abdominal aortic aneurysm

Beau Blois MD CCFP

Abstract

Objective To assess the efficacy of an office-based, family physician–administered ultrasound examination to screen for abdominal aortic aneurysm (AAA).

Design A prospective observational study. Consecutive patients were approached by nonphysician staff.

Setting Rural family physician offices in Grand Forks and Revelstoke, BC.

Participants The Canadian Society for Vascular Surgery screening recommendations for AAA were used to help select patients who were at risk of AAA. All men 65 years of age or older were included. Women 65 years of age or older were included if they were current smokers or had diabetes, hypertension, a history of coronary artery disease, or a family history of AAA.

Main outcome measures A focused "quick screen," which measured the maximal diameter of the abdominal aorta using point-of-care ultrasound technology, was performed in the office by a resident physician trained in emergency ultrasonography. Each patient was then booked for a criterion standard scan (ie, a conventional abdominal ultrasound scan performed by a technician and interpreted by a radiologist). The maximal abdominal aortic diameter measured by ultrasound in the office was compared with that measured by the criterion standard method. The time to screen each patient was recorded.

Results Forty-five patients were included in data analysis; 62% of participants were men. The mean age was 73 years. The mean pairwise difference between the office-based ultrasound scan and the criterion standard scan was not statistically significant. The mean absolute difference between the 2 scans was 0.20 cm (95% CI 0.15 to 0.25 cm). Correlation between the scans was 0.81. The office-based ultrasound scan had both a sensitivity and a specificity of 100%. The mean time to screen each patient was 212 seconds (95% CI 194 to 230 seconds).

Conclusion Abdominal aortic aneurysm screening can be safely performed in the office by family physicians who are trained to use point-of-care ultrasound technology. The screening test can be completed within the time constraints of a busy family practice office visit. The benefit of screening for AAA in rural patients might be great if local diagnostic ultrasound service and emergent transport to a vascular surgeon are not available.

EDITOR'S KEY POINTS

- The Canadian Society for Vascular Surgery advocates a single ultrasound abdominal aortic aneurysm (AAA) screening examination for all men 65 to 75 years of age. It also says that there is a benefit, albeit smaller, to screening all men older than 75 years, as well as women aged 65 years or older with multiple risk factors for vascular disease.
- Patients in rural areas often do not have access to services such as screening ultrasound or hospital-based or mobile screening programs using ultrasound technologists; furthermore, the rural population might also have a higher mortality rate from AAA rupture, as they are farther from the lifesaving emergency surgical services required to repair a ruptured AAA.
- The objective of this study was to evaluate the safety and efficacy of ultrasound examination of the abdominal aorta by a rural family physician to screen for AAA in the office. The results showed that screening for AAA can be effectively and efficiently achieved in the office by a rural physician trained in ultrasonography. According to the author, this procedure can be completed within the time constraints of a busy family practice office visit.

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Utilisation de l'échographie au bureau pour détecter les anévrysmes de l'aorte abdominale

Beau Blois MD CCFP

Résumé

Objectif Évaluer l'efficacité de l'échographie administrée au bureau par un médecin de famille comme moyen de détecter un anévrysme de l'aorte abdominale (AAA).

Type d'étude Étude d'observation prospective. Des patients consécutifs ont été approchés par des membres du personnel autres que des médecins.

Contexte Bureaux ruraux de médecins de famille à Grand Forks et à Revelstoke, C.-B.

Participants On s'est servi des recommandations de dépistage de la Société canadienne de chirurgie vasculaire pour faciliter le choix de patients à risque d'AAA. Tous les hommes de 65 ans ou plus ont été inclus. Les femmes de 65 ans ou plus l'ont été si elles étaient des fumeuses actives ou présentaient un diabète, de l'hypertension, une histoire de maladie coronarienne ou des antécédents familiaux d'AAA.

Principaux paramètres à l'étude Un dépistage rapide dirigé a été effectué au bureau par un médecin résident formé en échographie d'urgence grâce à une technique d'échographie de proximité. On a alors prévu pour chaque patient un *scan* standard servant de critère (c.-à-d. une échographie abdominale conventionnelle effectuée par un technicien et interprétée par un radiologiste). Le diamètre maximal de l'aorte abdominale mesuré par échographie au bureau a été comparé à celui mesuré par la méthode standard conventionnelle. Le temps nécessaire pour le dépistage a été enregistré.

Résultats On a retenu 45 patients pour l'analyse des données; 62 % des participants étaient des hommes. L'âge moyen était de 73 ans. La moyenne des différences entre les deux échographies, celle faite au bureau et l'échographie standard conventionnelle, n'était pas significative. En valeur absolue, la différence moyenne entre les deux échographies était de 0,20 cm (IC à 95% 0,15 à 0,25 cm). La corrélation entre les 2 examens était de 0,81. Les échographies faites au bureau avaient une sensibilité et une spécificité de 100%. Le temps moyen requis pour examiner chaque patient était de 212 secondes (IC à 95% 194 à 230 secondes).

Conclusion Le dépistage de l'anévrysme de l'aorte abdominale peut être effectué sans danger au bureau par des médecins de famille possédant la formation pour utiliser une technique d'échographie de proximité. L'examen de dépistage peut être effectué à l'intérieur des contraintes de temps d'une visite à un bureau de médecine familiale achalandé. Le dépistage de l'AAA chez des patients ruraux pourrait s'avérer très avantageux lorsque les services locaux d'échographie diagnostique et de transport rapide vers un chirurgien vasculaire ne sont pas disponibles.

Cet article a fait l'objet d'une révision par des pairs.
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POINTS DE REPÈRE DU RÉDACTEUR

- La Société canadienne de chirurgie vasculaire préconise un examen de dépistage de l'anévrysme de l'aorte abdominale (AAA) pour tous les hommes de 65 à 75 ans. Elle ajoute qu'il y a un avantage, quoique moindre, à dépister tous les hommes de plus de 75 ainsi que les femmes de 65 ans et plus qui présentent plusieurs facteurs de risque de maladie vasculaire.

- Les patients des régions rurales n'ont souvent pas accès à des services tels que l'échographie de dépistage ou aux programmes de dépistage hospitaliers ou mobiles utilisant des techniciens d'échographie; en outre, les patients des régions rurales pourraient avoir un taux de mortalité plus élevé en cas de rupture d'un AAA, puisqu'ils sont plus loin des services de chirurgie d'urgence nécessaires pour réparer une rupture d'AAA.

- Cette étude avait pour but de vérifier l'innocuité et l'efficacité d'un examen échographique de l'aorte abdominale effectué par un médecin de famille rural afin de dépister un AAA au bureau. Les résultats ont montré qu'un dépistage de l'AAA peut être effectué au bureau de façon efficace et efficiente par un médecin rural ayant une formation en échographie. D'après l'auteur, cet examen peut être complété à l'intérieur des contraintes de temps correspondant à une visite à un bureau de médecine familiale achalandé.

Abdominal aortic aneurysm (AAA) will affect 4% to 8% of men and 1.5% of women older than 60 years.[1] A high mortality rate of 80% to 90% is associated with rupture of AAA.[2] Currently, there are nationwide screening programs for AAA in the United States and the United Kingdom owing to the mortality benefit and cost-effectiveness associated with screening those at risk.[3-9] It has been estimated that 50% of AAA-related deaths could be prevented by national screening programs.[4] There are currently no AAA screening programs in Canada.

The Canadian Society for Vascular Surgery (CSVS) advocates a single ultrasound AAA screening examination for all men 65 to 75 years of age.[10] The CSVS also says there is a benefit, albeit smaller, to screening all men older than 75 years, as well as women 65 years of age or older with multiple risk factors for vascular disease.[10] These risk factors include smoking history, cerebrovascular disease, and family history of AAA.[11] There is no benefit to population-based screening of all women aged 65 years or older.[10] Though the argument for screening men 65 years of age and older is strong, rates of screening for AAA remain low, even in the United States.[12]

Organized screening programs reported in the literature have been successful in urban and rural environments.[13-17] These have been largely hospital-based or mobile screening programs using ultrasound technologists to perform the examinations. Patients in rural areas often do not have access to services such as ultrasound screening. They might have to travel long distances for diagnostic tests. A recent study found that most rural patients screened for AAA in their community were satisfied with the service.[15] The rural population might also have a higher mortality rate from AAA rupture, as they are farther from the lifesaving emergency surgical services required to repair a ruptured AAA.

Many family physicians who also work in emergency medicine now possess the skills to detect AAA using ultrasound, as ultrasound is becoming a valuable tool in emergency medicine diagnosis. Most such physicians work in office-based practices and could use their skills with the ultrasound machine to screen for AAA. The reality in Canada is that most eligible patients are not screened for AAA. Owing to wait times, family physicians are not routinely sending their patients to outpatient diagnostic imaging departments for conventional abdominal ultrasounds or computed tomography scans to screen for AAA.

Screening for AAA need not be an expensive or time-consuming endeavour. An ultrasound "quick screen" for AAA has been shown to be 100% sensitive and specific when compared with a conventional ultrasound, and only requires 4 minutes to perform.[18]

The objective of this study was to evaluate the safety and efficacy of ultrasound examination of the abdominal aorta by a rural family physician to screen for AAA in the office. No previous study has used a physician-administered quick screen for AAA in the office setting.

METHODS

A prospective observational study was performed in the rural communities of Grand Forks and Revelstoke, BC, from November 2009 to June 2010. Ethics approval was obtained from the ethics review board of the University of British Columbia in Vancouver. All patients provided signed, informed consent. Consecutive patients were recruited from family medicine and diabetes education clinics. A patient handout was provided as a recruitment tool in the waiting room of each clinic, and a nurse explained the study to each patient. Patients then booked office visits with the author if they were interested in participating. The author ensured that each participant was fully informed about the research. Signed consent was obtained during the visit if it had not already been provided.

The patients were chosen based on the CSVS AAA screening recommendations. All were 65 years of age or older, and women were excluded if they did not have at least 1 of the following risk factors: diabetes, hypertension, current smoking habits, history of coronary artery disease, or family history of AAA. Patients with known AAA were also excluded. This study had broader inclusion criteria than the CSVS recommended. Patients who would derive less benefit from the test (such as men older than 75 years and women with only 1 risk factor) were included in this research to increase the number of participants in a time-limited resident research study.

Demographic data were obtained for all patients before ultrasonography. Patients were not asked to fast before the screening scan. If the first examination was limited by bowel gas, they were brought back for another examination after fasting for at least 4 hours. All screening ultrasonography was performed on the office examining table. The scan consisted of a focused ultrasonographic examination of the aorta using the quick-screen method previously described by Lee et al.[18] A SonoSite TITAN machine with a C60 curved array probe was used for all screening tests. The manufacturer states that no calibration of this ultrasound machine is necessary. The aorta of each patient was visualized from above the level of the renal arteries to the bifurcation. Patients were scanned in the horizontal and sagittal planes. The largest of the anterior-posterior and transverse measurements was recorded from the image in centimetres to 2 decimal places. Each patient only needed to expose the anterior abdomen from the costal margin to just below the umbilicus in the midline.

The amount of time required to screen each patient was also recorded. For purposes of comparison, only the scanning time was recorded, from the time the ultrasound machine was turned on to when it was turned off. Patient preparation time was not recorded. Each patient was then booked for a conventional abdominal ultrasound performed by an ultrasound technologist at the local hospital who measured the maximal aortic diameter. A radiologist later reviewed these results. For this study, an AAA was defined as a focal dilatation of the aorta greater than 3 cm. The CSVS recommends follow-up ultrasound to monitor growth if the aortic diameter exceeds 3 cm. Aortic diameters of less than 3 cm at time of screening warrant no further follow-up.[10]

Training by the author for the quick-screen method was initially undertaken informally during the first year of a rural family medicine residency. This happened during routine patient encounters in the emergency medicine department in Kelowna, BC. Preceptors who were trained in ultrasound scanning of the abdomen for AAA demonstrated the technique and supervised the author while he performed the scans on patients for whom the test would aid in their management. The author then took an emergency ultrasonography course presented by a national organization, and completed 50 ultrasonographer-supervised scans of the aorta.

The target sample size was based on a paired *t* test to detect a small-to-medium effect size of 0.4 (difference of 0.4 SDs between the criterion standard scan and office-based scan means) with 80% power and 5% 2-tailed significance. For a 95% CI for the correlation between scans, this sample size also leads to a margin of error of 0.2, assuming a true correlation of 0.8.

Aortic diameters were summarized with 95% CIs for means. The 2 scans were compared using a paired *t* test and correlation coefficient. Microsoft Excel was used for all data analyses.

RESULTS

During the study period, 47 patients were recruited and screened for AAA in the family physician office. One patient did not follow up for the criterion standard examination, and 1 patient had the criterion standard scan, but the ultrasonographer did not record the maximal aortic diameter during the examination for comparison. Thus, data for 45 patients were available for analysis. Of these, 28 (62%) were men and 17 (38%) were women. The mean (SD) age was 73 (5.6) years (95% CI 71.3 to 74.7 years), with a range of 65 to 87 years. Most patients had hypertension and almost half had diabetes (**Table 1**). One-quarter of men (7 of 28) had no risk factors other than age, while 6 of 17 women (35%) had only 1 risk factor. Thirteen of 45 participants (29%) were older than 75 years. Men and women were not significantly different with regard to any of these factors.

Table 1. Demographic characteristics of the study participants

CHARACTERISTIC	MEN (N = 28)	WOMEN (N = 17)
Mean age (95% CI), years	73.5 (71.1–75.9)	72.1 (69.7–74.5)
Patients > 75 years, %	28	29
Only 1 risk factor, %	25	35
Diabetes, %	39	47
Hypertension, %	57	70
Family history of abdominal aortic aneurysm, %	7	11
Current smokers, %	7	6
History of coronary artery disease, %	11	35

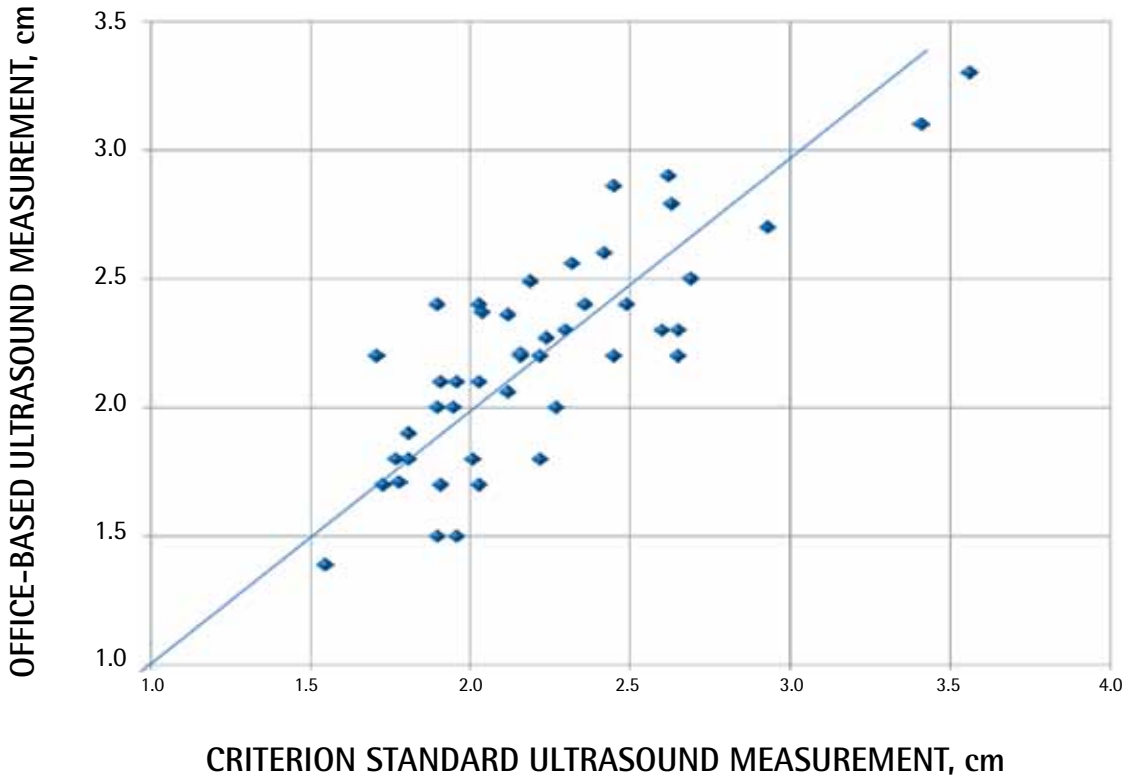
The mean (SD) length of time to scan each patient was 212 (59) seconds (95% CI 194 to 230 seconds). The mean maximal aortic diameter for the office-based screen was 2.22 cm (95% CI 2.09 to 2.35 cm). The mean aortic diameter for the criterion standard scan was 2.20 cm (95% CI 2.07 to 2.33 cm). A pairwise comparison of the office-based scan with the criterion standard scan using a paired *t* test showed that the mean difference of 0.02 cm was not statistically significant ($P = .67$; 95% CI -0.06 to 0.10). As well, the mean absolute difference between the 2 scans for each patient was 0.20 cm (95% CI 0.15 to 0.25 cm). None of the measurements exceeded 0.5 cm in absolute difference. A scatter plot (**Figure 1**) displays the agreement between the 2 scans; the 45° angle is a reference for perfect agreement. In half the pairs (23 of 45), the office-based measurement exceeds the criterion standard measurement; these points appear above the reference line. The correlation coefficient between the 2 measurements is 0.81. Simple linear regression to predict the office-based measurement from the criterion standard measurement found a slope of 0.80 which is significantly different ($P = .03$) from a slope of 1 (representing perfect agreement).

Two patients (4.4%) were found to have AAAs of between 3 and 4 cm in diameter. Two patients had examinations that were limited by intraluminal bowel gas. They were brought back for another examination after fasting for more than 4 hours, at which time successful screening tests were performed.

DISCUSSION

This study showed that screening for AAA can be effectively and efficiently achieved in an office setting by a rural physician trained in ultrasonography.

Figure 1. Maximal aortic diameter measured by office-based ultrasound versus the criterion standard. *The 45° line on the scatter plot is a reference for perfect agreement between the new office-based measurement and the conventional criterion standard measurement of maximal aortic diameter.*



Ultrasound is a very accurate method of measuring aortic diameter. When compared with computed tomography and intraoperative measurements it tends to underestimate smaller aortic diameters and overestimate larger aortic diameters.[19] It is more accurate for distal aortic measurements than those made above the level of the renal arteries.[20] The acceptable interobserver variability is 0.3 to 0.5 cm.[20-22] In keeping with the published research, the findings of this study demonstrated a mean absolute interobserver variability of 0.20 cm (95% CI 0.15 to 0.25 cm). All interobserver measurements in this study had an absolute difference of less than 0.5 cm. The office-based ultrasound scan identified the 2 patients with AAAs of greater than 3 cm in diameter as determined by the criterion standard scan. There were no false positives. This demonstrates both a sensitivity and a specificity of 100% for the office-based screening scan (**Table 2**). This is the same sensitivity and specificity found using the quick-screen method in other research.[18]

The prevalence of AAA in this study (4.4%) reflects that found in the literature.[1,5,9] Patients with AAAs received the usual care as per the CSVS recommendations.[10] Patients are not usually considered for operative repair until the aneurysms are greater than 5 to 5.5 cm in diameter. No patient in this study had an aortic diameter greater than 5 cm. The published prevalence of AAA greater than 5 cm in diameter is 0.4%.[9]

In 1988, R.A. Filly speculated that ultrasound scanning might become the stethoscope of the future, "used by many, understood by few."[23] In the intervening 22 years, what has research said about ultrasound examination of the aorta by nonradiologist physicians? A study in 2005 showed that emergency medicine residents could accurately diagnose AAA and measure the maximal aortic diameter.[24] All of these residents had completed at least 150 scans of any type and had participated in didactic teaching. Ultrasonographic measurements of the aorta by emergency department physicians were determined to

Table 2. A 2 × 2 table showing the correlation between the office-based scan and the criterion standard scan: *No true positives were missed by the office-based scan, and no false positives were identified.*

		CRITERION STANDARD SCAN	
ULTRASOUND OF AORTA FOR MAXIMAL AORTIC DIAMETER > 3 CM*		POSITIVE FOR AAA, N	NEGATIVE FOR AAA, N
OFFICE-BASED SCAN	POSITIVE FOR AAA, N	2	0
	NEGATIVE FOR AAA, N	0	43

AAA—abdominal aortic aneurysm.
*An AAA was defined as a focal dilatation of the aorta > 3 cm.

effectively approximate measurements by computed tomography.[25] The findings of this study also support the use of ultrasound by trained physicians to image the aorta. Perhaps, like the stethoscope, ultrasound would become ubiquitous if more health professionals were trained in its use for practical applications such as screening for AAA.

Family physicians are often under time constraints while practising in the office. New screening tests are more likely to be implemented if these tests are time efficient. The findings of this study suggest that screening for AAA is an examination that can be performed within the constraints of a 10- to 15-minute visit at a busy family medicine practice. The average time of 212 seconds (95% CI 194 to 230 seconds) in this study was comparable with the previously reported time of 4 minutes (95% CI 3.4 to 4.6 minutes) for a focused abdominal aorta quick screen[18] and 4.6 minutes (95% CI 2.3 to 6.9 minutes) using a portable ultrasound device.[26]

This study supports the argument for office-based screening for AAA as a part of better patient-centred care. The decreased wait times associated with a screening test performed in the family physician's office compared with a conventional abdominal ultrasound could be substantial in some locations.

Rural patients have the most to gain from physicians offering this test in the office. As AAA rupture requires timely repair for increased survival, rural patients are at a considerable risk of death from rupture owing to increased transfer times. As well, the rural population often has decreased access to diagnostic testing services such as ultrasonography. This paper supports office-based point-of-care testing that offers increased access to AAA screening.

Family physicians routinely screen for diseases such as cervical cancer, hypertension, and diabetes in the office setting. Currently, there is no national AAA screening program. Perhaps we should consider including AAA in our screening practices. With the proven mortality benefit and cost-effectiveness, there is good evidence to support this examination for all men aged 65 years or older.[3-9] Perhaps it could be implemented as part of the full physical examination of all men of that age.

Training for point-of-care ultrasound diagnosis is currently provided by at least 2 national organizations that tailor the training of emergency physicians—the Canadian Emergency Ultrasound Society and the Canadian Association of Emergency Physicians. They offer class-based and hands-on training undertaken over the span of a weekend. These organizations recommend that learners complete 50 supervised scans to ensure their proficiency. Ultrasound examination of the aorta is, in the opinion of the author, among the easier techniques to master.

Canadian family physicians who are trained in this diagnostic examination are in a position to take ownership of screening for AAA. This study showed that point-of-care screening for AAA with office-based ultrasound by a trained physician is accurate and efficient. However, a more detailed evaluation of cost and remuneration opportunities should be explored before family physicians adopt this method of screening.

Limitations

First, owing to the time constraints imposed because this project was part of a residency program, the overall number of participants was small. Second, a single physician performed all the screening ultrasonography. Third, this study used borrowed equipment, which did not allow an evaluation of the feasibility for other physicians to use this screening method.

Conclusion

The CSVS recommendations for AAA screening can be safely met in the office by family physicians who are trained to use point-of-care ultrasound technology. The screening test can be completed within the time constraints of a busy family practice office visit. Screening by family physicians for AAA might greatly benefit rural populations. Further research should be undertaken to assess the effect of family physicians implementing AAA screening programs within their practices.

Dr Blois is a family physician practising at Colchester Regional Hospital in Truro, NS.

Competing interests
Dr Blois borrowed ultrasound equipment from SonoSite, Inc, free of charge to complete this study.

Correspondence
Dr Beau Blois, Colchester Regional Hospital, Emergency Department, 207 Willow St, Truro, NS B2N 5A1; telephone 902 956-9564; e-mail **beau.blois@dal.ca**

References

1. Krupski WC, Rutherford RB. Update on open repair of abdominal aortic aneurysms: the challenges for endovascular repair. *J Am Coll Surg* 2004;199(6):946-60.
2. Longo C, Upchurch GR Jr. Abdominal aortic aneurysm screening: recommendations and controversies. *Vasc Endovascular Surg* 2005;39(3):213-9.
3. Fleming C, Whitlock EP, Beil TL, Lederle FA. Screening for abdominal aortic aneurysm: a best-evidence systematic review for the U.S. Preventive Services Task Force. *Ann Intern Med* 2005;142(3):203-11.
4. Thompson SG, Ashton HA, Gao L, Scott RA; Multicentre Aneurysm Screening Study Group. Screening men for abdominal aortic aneurysm: 10 year mortality and cost effectiveness results from the randomised Multicentre Aneurysm Screening Study. *BMJ* 2009;338:b2307.
5. Ashton HA, Buxton MJ, Day NE, Kim LG, Marteau TM, Scott RA, et al. The Multicentre Aneurysm Screening Study (MASS) into the effect of abdominal aortic aneurysm screening on mortality in men: a randomised controlled trial. *Lancet* 2002;360(9345):1531-9.
6. Kim LG, Scott RA, Ashton HA, Thompson SG; Multicentre Aneurysm Screening Study Group. A sustained mortality benefit from screening for abdominal aortic aneurysm. *Ann Intern Med* 2007;146(10):699-706.
7. Cosford PA, Leng GC. Screening for abdominal aortic aneurysm. *Cochrane Database Syst Rev* 2007;(2):CD002945.
8. Montreuil B, Brophy J. Screening for abdominal aortic aneurysms in men: a Canadian perspective using Monte Carlo-based estimates. *Can J Surg* 2008;51(1):23-34.
9. Lee ES, Pickett E, Hedayati N, Dawson DL, Pevec WC. Implementation of an aortic screening program in clinical practice: implications for the Screen For Abdominal Aortic Aneurysms Very Efficiently (SAAAVE) Act. *J Vasc Surg* 2009;49(5):1107-11.
10. Mastracci TM, Cinà CS; Canadian Society for Vascular Surgery. Screening for abdominal aortic aneurysm in Canada: review and position statement of the Canadian Society for Vascular Surgery. *J Vasc Surg* 2007;45(6):1268-76, 1276.e1-5.
11. Lovell MB, Harris KA, Derose G, Forbes TL, Fortier M, Scott B. A screening program to identify risk factors for abdominal aortic aneurysms. *Can J Surg* 2006;49(2):113-6.
12. Federman DG, Carbone VG, Kravetz JD, Kancir S, Kirsner RS, Bravata DM. Are screening guidelines for abdominal aortic aneurysms being implemented within a large VA primary health care system? *Postgrad Med* 2009;121(1):132-5.
13. Mani K, Alund M, Björck M, Lundkvist J, Wanhainen A. Screening for abdominal aortic aneurysm among patients referred to the vascular laboratory is cost-effective. *Eur J Vasc Endovasc Surg* 2010;39(2):208-16. Epub 2009 Nov 25.
14. Ogata T, Arrington S, Davis PM, Sam AD 2nd, Hollier LH, Tromp G, et al. Community-based, nonprofit organization-sponsored ultrasonography screening program for abdominal aortic aneurysms is effective at identifying occult aneurysms. *Ann Vasc Surg* 2006;20(3):312-6. Epub 2006 Apr 27.
15. Lesjak MS, Flecknoe-Brown SC, Sidford JR, Payne K, Fletcher JP, Lyle DM. Evaluation of a mobile screening service for abdominal aortic aneurysm in Broken Hill, a remote regional centre in far western NSW. *Aust J Rural Health* 2010;18(2):72-7.
16. Jamrozik K, Norman PE, Spencer CA, Parsons RW, Tuohy R, Lawrence-Brown MM, et al. Screening for abdominal aortic aneurysm: lessons from a population-based study. *Med J Aust* 2000;173(7):345-50.
17. Lindholt JS, Juul S, Henneberg EW, Fasting H. Is screening for abdominal aortic aneurysm acceptable to the population? Selection and recruitment to hospital-based mass screening for abdominal aortic aneurysm. *J Public Health Med* 1998;20(2):211-7.
18. Lee TY, Korn P, Heller JA, Kilaru S, Beavers FP, Bush HL, et al. The cost-effectiveness of a "quick-screen" program for abdominal aortic aneurysms. *Surgery* 2002;132(2):399-407.
19. Singh K, Jacobsen BK, Solberg S, Kumar S, Arnesen E. The difference between ultrasound and computed tomography (CT) measurements of aortic diameter increases with aortic diameter: analysis of axial images of abdominal aortic and common iliac artery diameter in normal and aneurysmal aortas. The Tromsø Study, 1994-1995. *Eur J Vasc Endovascr Surg* 2004;28(2):158-67.
20. Singh K, Bønaa KH, Solberg S, Sørlie DG, Bjørk L. Intra- and interobserver variability in ultrasound measurements of abdominal aortic diameter. The Tromsø Study. *Eur J Vasc Endovasc Surg* 1998;15(6):497-504.
21. Lederle FA, Wilson SE, Johnson GR, Reinke DB, Littooy FN, Acher CW, et al. Variability in measurement of abdominal aortic aneurysms. Abdominal Aortic Aneurysm Detection and Management Veterans Administration Cooperative Study Group. *J Vasc Surg* 1995;21(6):945-52.
22. Pleumeekers HJ, Hoes AW, Mulder PG, van der Does E, Hofman A, Laméris JS, et al. Differences in observer variability of ultrasound measurements of the proximal and distal abdominal aorta. *J Med Screen* 1998;5(2):104-8.
23. Filly RA. Ultrasound: the stethoscope of the future, alas. *Radiology* 1988;167(2):400.
24. Costantino TG, Bruno EC, Handly N, Dean AJ. Accuracy of emergency medicine ultrasound in the evaluation of abdominal aortic aneurysm. *J Emerg Med* 2005;29(4):455-60.
25. Knaut AL, Kendall JL, Patten R, Ray C. Ultrasonographic measurement of aortic diameter by emergency physicians approximates results obtained by computed tomography. *J Emerg Med* 2005;28(2):119-26.
26. Bruce CJ, Spittell PC, Montgomery SC, Bailey KR, Tajik AJ, Seward JB. Personal ultrasound imager: abdominal aortic aneurysm screening. *J Am Soc Echocardiogr* 2000;13(7):674-9.

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