Leveraging the electronic medical record to implement an abdominal aortic aneurysm screening program

Robert J. Hye, MD, Andrea E. Smith, MSN, RN, PHN, Gary H. Wong, MD, MPH, Southida S. Vansomphone, PharmD, Ronald D. Scott, MD, and Michael H. Kanter, MD, San Diego, Pasadena, Fontana, Downey, and West Los Angeles, Calif

Objective: Screening for abdominal aortic aneurysms (AAAs) reduces aneurysm-related mortality and has been recommended by the U.S. Preventive Services Task Force and American Heart Association since 2005. Medicare has covered a one-time screening ultrasound for new male enrollees with a familial or smoking history since 2007. Nevertheless, in the U.S., screening has remained underutilized. Review of patients with ruptured AAA in our system in 2007 showed the majority were undiagnosed, yet met U.S. Preventive Services Task Force and American Heart Association screening guidelines. To reduce the number of preventable AAA ruptures and deaths in our patients, we implemented an AAA screening program using our electronic medical record (EMR). This study describes the design, implementation, and early results of that screening program.

Methods: Between March 2012 and June 2013, men aged 65 to 75 years with any history of smoking were targeted for screening. Medical records were reviewed electronically to exclude patients with abdominal imaging studies within 10 years that would have diagnosed an AAA. Best practice alerts (BPA) were created in the EMR so when an appropriate patient is seen, office staff and providers are prompted to order an aortic ultrasound. AAA was defined as aortic diameter ≥3.0 cm or greater, and ultrasound reports contained a standard template providing guidance for patient management when an aneurysm was identified. Newly identified AAAs were triaged for vascular surgery consultation or follow-up with their primary physician. The number of eligible patients, unscreened patients, and AAAs identified were tabulated by our Regional Outpatient Safety Net Program.

Results: In a population of 3.6 million, 55,610 patients initially met screening criteria, and 26,837 (48.26%) were excluded from the BPA because of prior abdominal imaging studies. After 15 months, there were 68,164 patients who met screening criteria, 54,356 (79.74%) of whom had undergone an abdominal imaging study. Thus, 27,519 patients underwent an imaging study after the BPA was activated. During the study period, 731 new AAAs were diagnosed, 165 over 4.0 cm in diameter. Screening rates have increased at all medical centers where the BPA was activated, and the percentage of unscreened patients has been reduced from 51.74% to 20.26% system-wide.

Conclusions: In an integrated health care system using an EMR, AAA screening can be implemented with a dramatic reduction in unscreened patients. Further analysis is required to assess the impact of the screening program on AAA rupture rate and cost-effectiveness in our system. (J Vasc Surg 2014;1-9.)

Death due to rupture of abdominal aortic aneurysm (AAA) occurs in approximately 10,000 patients in the United States each year. The majority of AAAs are asymptomatic until shortly before rupture, making detection and repair prior to the event the most effective means of reducing aneurysm-related morbidity and mortality. In most patients, screening with simple abdominal ultrasound will identify an AAA and is a non-invasive, cost-effective technique that has been shown in several studies to reduce AAA-related mortality in at risk populations. Based on this evidence, since 2005, the U.S. Preventive Services Task Force (USPSTF) and the American Heart Association (AHA) have recommended screening in men aged 65 to 75 years of age with any history of smoking. More recent follow-up studies of the screened populations have demonstrated long term reduction in AAA-related mortality, all-cause mortality, and cumulative cost-effectiveness associated with AAA screening. Screening guidelines have been proposed by multiple additional groups but are generally broader in scope and have used less rigorous methodology.

Evidence for the efficacy of screening combined with the recommendations above led to the passage of the Screen for Abdominal Aortic Aneurysms Very Efficiently (SAAAVE) Act by the Federal Government. This law,
enacted in 2007, provided payment for a single ultrasound screening exam for new male Medicare enrollees with a history of smoking more than 100 cigarettes and for females with a family history of AAA disease. No similar benefit was extended for existing Medicare participants. At about the same time, The Department of Veterans Affairs (VA) also mandated a system-wide screening program to include all eligible patients, not just new enrollees. For a variety of reasons, neither of these federal programs appears to have been effective in achieving their goal of screening high volumes of the target population, and it is estimated that less than 15% of eligible Medicare patients are being screened.\textsuperscript{13,14}

While screening and identification of the patient with an AAA is the most critical aspect in reducing morbidity and mortality associated with ruptured AAA, most of the AAs that are found will be small and not require immediate repair. Therefore, any screening program must also have an equally effective tracking mechanism so that patients can be followed and scheduled to undergo reimaging at appropriate intervals.

The computerized electronic medical record (EMR) has the potential to enhance screening programs by allowing rapid review of demographics, risk factors, and prior imaging studies to separate those in need of screening from those with an already known diagnosis or adequate previous imaging exams that would exclude the diagnosis. Additionally, clinical reminders can be generated to prompt clinicians to order appropriate studies when indicated, and patients can be effectively tracked over time. Several small series have reported the utility of the EMR in AAA screening, including the VA Healthcare System in this country, and it has been suggested that other systems with a developed EMR should consider using it for screening.\textsuperscript{15–17}

Kaiser Permanente (KP) is an integrated health care organization that cares for over 9 million patients nationwide, 3.6 million in Southern California. There is a strong history of practicing high quality preventive care and population based medicine.\textsuperscript{18,19} In 2007, AAA-related mortality was reviewed in KP Southern California, and it was determined that the number of ruptured AAs in our patient population was higher than was desired, given that there was evidence that screening can reduce AAA-related mortality. Review of the cases revealed that the majority of patients presenting with ruptured AAA had not been known to have an aneurysm. A small but not insignificant minority of cases were noted in patients with known AAA that had been lost to follow-up, refused surgery, or were felt to be too high risk for repair. Although clinical practice guidelines for screening were already in place in our system, they were not being adequately followed. On the basis of the 2007 review, the vascular surgery divisions, in conjunction with regional leadership, developed plans to implement a more effective screening program for AAs. During 2005 and 2006, a comprehensive EMR had been implemented throughout all of KP’s outpatient and inpatient facilities. The EMR contains a robust ability to provide clinical reminders to practitioners for a variety of clinical conditions during patient visits and was identified as the ideal mechanism to improve screening within our health care system. Concomitantly, it was decided to use an existing outpatient safety net program, designed to prevent loss of patients with chronic conditions to follow-up, to track the small and unrepaired AAA patient population. This paper describes the development of the screening and tracking program, as well as the early results of these efforts.

METHODS

Based on USPSTF and AHA guidelines, male patients between the ages of 65 and 75 years with any history of current or past smoking were selected as the target population. Review of existing databases and charts of all patients included in the study was conducted under a protocol approved by the Institutional Review Board of Kaiser Permanente Southern California. To avoid unnecessary ordering of screening exams, it was assumed that patients with known or repaired AAs would likely have had an abdominal imaging study within the past 10 years. It was also assumed that if a patient had an abdominal imaging study within 10 years and was not diagnosed with an AAA, then screening was not required. Therefore, we selected patients in the target population for screening who had no record of an abdominal imaging study in the past 10 years (Table 1). KP uses a tool called the “Proactive Office Encounter” (POE) where office nursing staff see a list of “care gaps” when patients are seen in the office.\textsuperscript{20} The POE is proprietary software developed by KP that extracts data from the EMR and processes it further. Identification of these care gaps prompts the staff to remind patients to follow-up on previously ordered tests or to assist patients in scheduling screening exams such as mammography or blood tests when indicated. A “Best Practice Alert” (BPA) was created within the EMR as part of the POE process that would be visible to the nursing staff when patients in need of AAA screening were checked in for visits with a practitioner. This allowed the staff to enter an order for a screening aortic ultrasound that the clinician could then sign when signing any orders for the patient at the time of closing the chart (Fig 1).

An aortic diameter of \(\geq 3.0\) cm was used as the definition of an AAA, and an aortic diameter of 2.5 to 2.9 cm was considered aortic ectasia. Included at the end of the report for all aortic ultrasounds or other imaging studies demonstrating an aortic aneurysm in our organization is a follow-up algorithm for AAA management (Fig 2). An additional benefit of the EMR is that it allows the physician to easily order follow-up imaging studies at specified intervals up to 36 months in advance.

KP in Southern California has had a Regional Outpatient Safety Net (ROSN) program since 2009. The ROSN is a program that capitalizes on the EMR to systematically identify members who have inadvertent lapses in care using a small, centralized team to intervene before the patient experiences any harm. It was elected to place responsibility for oversight of the tracking component of the screening program in this department. The EMR is
leveraged to generate a list of patient with a diagnosis of AAA (Table II), as well as the follow-up imaging studies and vascular surgery consultations that they may have had. The data is refreshed monthly to capture newly diagnosed patients and the most recent follow-up (imaging and vascular surgery consultations). When no follow-up has been detected for 12 months in the EMR, the ROSN registered nurse reviews the chart of each patient and documents the size of the AAA. For patients with aortic diameters of 3.0 to 3.9 cm, the nurse places an order to be co-signed by the primary care physician for a follow-up ultrasound of the abdominal aorta. For aortic diameters of 4.0 to 5.9 cm, a routine vascular surgery consultation is generated, and if the aortic diameter is ≥6.0 cm, an urgent vascular surgery consultation (within 1 week in the absence of symptoms) is requested. For patients diagnosed with aortic ectasia (aortic diameter 2.5 to 2.9 cm), appropriate follow-up and risk factor modification is confirmed, with notification of the patient’s primary physician as required. The ROSN program does not bear primary responsibility for patient tracking but functions in the background to verify that appropriate follow-up is being performed.

The BPA was activated in March of 2012 in 10 of 13 of our medical centers. Two centers were activated about 8 months and 12 months later, while one remains unactivated. Analysis of the results of screening was conducted between March, 2012 and June, 2013. The number of patients in the target population, the number with abdominal imaging studies, and the total number and sizes of new AAAs diagnosed were tabulated quarterly.

<table>
<thead>
<tr>
<th>CPT code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>72131</td>
<td>CMPT TOMOGRAPHY LUMBAR SPINE; W/O CONTRST MATERIAL</td>
</tr>
<tr>
<td>72132</td>
<td>CMPT TOMOGRAPHY LUMBAR SPINE; W/CONTRST MATERIAL</td>
</tr>
<tr>
<td>72133</td>
<td>CT LUMB SPN; W/O &amp; W/CONTRST &amp; OTH SECT</td>
</tr>
<tr>
<td>72148</td>
<td>MR IMAG SP CANAL&amp;CONTENTS LUMB; W/O CONTRST MATL</td>
</tr>
<tr>
<td>72149</td>
<td>MR IMAG SP CANAL&amp;CONTENTS LUMB; W/CONTRST MATL</td>
</tr>
<tr>
<td>72158</td>
<td>MRI SPINAL CANAL W/O THEN W/CONTRAST; LUMBAR</td>
</tr>
<tr>
<td>74150</td>
<td>CMPT TOMOGRAPHY ABD; WITHOUT CONTRST MATERIAL</td>
</tr>
<tr>
<td>74160</td>
<td>CMPT TOMOGRAPHY ABDOMEN; W/CONTRAST MATERIAL</td>
</tr>
<tr>
<td>74170</td>
<td>CT ABD; W/O CONTRST FLW CONTRST&amp;FURTHER SECT</td>
</tr>
<tr>
<td>74175</td>
<td>CT ANGIOGRAPHY ABDOMEN W/CONTRAST/NONCONTRAST</td>
</tr>
<tr>
<td>74176</td>
<td>CT ABD &amp; PELVIS W/O CONTRST</td>
</tr>
<tr>
<td>74177</td>
<td>CT ABD &amp; PELVIS W/CONTRST</td>
</tr>
<tr>
<td>74178</td>
<td>CT ABD &amp; PELVIS W/O CONTRST 1+ BODY REGNS</td>
</tr>
<tr>
<td>74181</td>
<td>MR. IMAGING ABDOMEN; WITHOUT CONTRST MATERIAL</td>
</tr>
<tr>
<td>74182</td>
<td>MR IMAGING ABDOMEN; WITH CONTRST MATERIAL</td>
</tr>
<tr>
<td>74183</td>
<td>MRI ABD W/O &amp; W/CONTRAST &amp; FURTHER SEQUENCES</td>
</tr>
<tr>
<td>74185</td>
<td>MRA ABD C+MATRL</td>
</tr>
<tr>
<td>76700</td>
<td>US ABDOMINAL R-T W/IMAGE DOCUMENTATION</td>
</tr>
<tr>
<td>83975</td>
<td>DUPLEX SCAN IN-OUTFLO ABD/PELV ORGAN; CMPL STUDY</td>
</tr>
<tr>
<td>83978</td>
<td>DUPLEX SCAN OF AORTA, INFERIOR VENA CAVA, ILIAC VASCULATURE, OR BYPASS GRAFTS; COMPLETE STUDY</td>
</tr>
<tr>
<td>83979</td>
<td>UNILATERAL OR LIMITED STUDY</td>
</tr>
<tr>
<td>74174</td>
<td>COMPUTED TOMOGRAPHIC ANGIOGRAPHY ANGIOGRAPHY, ABDOMEN AND PELVIS, WITH CONTRAST MATERIAL(S), INCLUDING NONCONTRAST IMAGES</td>
</tr>
</tbody>
</table>

ABD, Abdomen; CMPL, complete; CMPT, computed; CONTRST, contrast; CT, computed tomography; C+MATRL, with contrast material; FLW, followed by; IMAG, image; IN-OUTFLO, inflow and outflow; LUMB, lumbar; MR, magnetic resonance; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; OTH, other; PELV, pelvis; REGNS, regions; R-T, real time; SECT, section; SP, spinal; SPN, spine; TOMOGRAPH, tomography; W/O, without; W/, with.
The number and percentages of remaining unscreened patients at each medical center was also monitored and recorded quarterly.

RESULTS

When the program was activated in KP Southern California in March 2012, there were a total of 55,610 patients within the target population. Of this group, 26,837 (48.26%) were identified as having an abdominal imaging study in the past 10 years, leaving 28,733 (51.74%) who required screening. For this group, the BPA was activated within the POE so that practitioners would be prompted to order an aortic ultrasound during clinic visits. By the end of June, 2013, a total of 68,164 patients were identified within the study group, and 54,356 (79.74%) had undergone abdominal imaging, including the 26,837 initially excluded from screening of the BPA, leaving only 13,808 (20.26%) unscreened. The relatively large increase in the target population is believed to be due to a combination of an absolute increase in the population and improved capture of smoking history. Following activation of the BPA, there was a dramatic (seven-fold over 5 months) increase in the number of aortic ultrasound requests being made to our departments of radiology, overwhelming some of them with volume in the short term. Concomitantly, there was both a large increase in queries to vascular surgery regarding small aneurysm management and referrals to vascular surgery for evaluation of AAAs in general. These increased volumes were absorbed into the system by committed and innovative work on the part of our radiology departments, radiologists, and vascular surgeons, and volumes are now at a more consistent baseline.

During the 15 months of the study, there was a marked decrease in the number of unscreened patients in our system, with an aggregate regional decline in unscreened patients from 51.74% to 20.26% (Fig 3). The effectiveness of the EMR prompts is highlighted by the marked difference in the percentage of unscreened patients in the three medical centers where BPA activation was delayed or did not occur. In centers where the BPA was activated, the rate of decrease in unscreened patients was remarkably similar. During the study period, 731 new diagnoses of AAAs were made in KP Southern California, with a typical...
distribution of size ranges (Table III). As anticipated, the majority of the aneurysms are small and are now being followed by the patient’s primary physicians with back-up from the ROSN program. These newly diagnosed aneurysms were found not only through the screening program, but were also incidental findings on other abdominal imaging studies or were diagnosed as a consequence of imaging studies ordered by practitioners who suspected the presence of an aneurysm. Our present system does not allow us to determine how many of the AAAs were discovered solely through the screening process. Although the preponderance of AAAs were small, 165 (22.6%) were of a size meriting referral for vascular surgery consultation and possible repair in appropriate risk patients with larger aneurysms.

The precise cost of the program was not determined, but the estimated cost of the additional ultrasound studies and administrative overhead in the first year was about $3 million, with <10% due to personnel expenditures. We estimate annual future costs to be about 50% of the first year figure.

**DISCUSSION**

Screening for AAAs has been shown to be effective in reducing aneurysm-related mortality and all-cause mortality in populations where it has been employed.\(^2\)\(^-\)\(^5\),\(^8\)-\(^10\)

AAA screening has also been shown to be equally or even more cost-effective than other widely accepted screening programs such as for colon and breast cancer.\(^3\),\(^8\)

Nevertheless, despite federal legislation to promote and pay for the cost, screening for AAAs has not been broadly

<table>
<thead>
<tr>
<th>AAA size</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>731</td>
</tr>
<tr>
<td>3.0 to 3.9 cm</td>
<td>566</td>
</tr>
<tr>
<td>4.0 to 4.9 cm</td>
<td>119</td>
</tr>
<tr>
<td>5.0 to 5.9 cm</td>
<td>28</td>
</tr>
<tr>
<td>≥6.0 cm</td>
<td>18</td>
</tr>
</tbody>
</table>
implemented in the U.S. The cause of this is multifactorial, but contributing factors are a fragmented health care system, provision for screening only at the time of Medicare enrollment, dependence on individual physicians to be aware of and order the screening studies, and lack of awareness on the part of the public of AAA disease and its risk factors. The SAAAVE act does not provide a mechanism for direct patient notification regarding the option of having a screening ultrasound if they are in an at-risk population. Although the National Committee for Quality Assurance requires public reporting on a variety of cardiovascular metrics, reporting of AAA screening rates is not a requirement.

An EMR utilized in an integrated health care system provides an ideal opportunity to establish an effective screening and tracking program with the potential to reduce aneurysm-related morbidity and mortality. Leveraging of these electronic assets also allows the program to be established and operate with relatively little in the way of additional human administrative resources.

The experience in KP Southern California using the EMR to facilitate implementation of an AAA screening program clearly shows the effectiveness of this approach. It should be noted that, since the vast majority of the Medicare population in KP is capitated, the provisions of the SAAAVE Act were not an incentive and did not impact our ability to implement an effective screening program. Within 15 months of beginning our screening program, the percentage/number of unscreened patients has fallen from 51.74% to 20.26%. Additionally, 731 new AAAs have been detected. Of course, the most important impact of an AAA screening program is to reduce the number of ruptured AAAs in a population. At this point, we have not analyzed the impact of our screening program on the AAA rupture rate in our system, but that analysis is planned after the program has been in place for a longer period of time.

Kaiser Permanente has some additional unique characteristics that may make it difficult to duplicate these results in other environments. First, the EMR is in use throughout all inpatient and outpatient facilities in the system so that all practitioners have readily available access to the patient’s complete medical record and clinical reminders, regardless of geographic location. When the back office staff enters an order via the POE process, the practitioner can respond easily and quickly by simply signing the order for the screening study. In contrast, the system reported on by Meyer et al17 depended on the individual practitioner initiating the order. We believe this difference is responsible for the high success rate observed in our study. In addition, our group has been very selective in using BPAs within the POE to avoid desensitizing the staff to the importance of the alert. Finally, our medical group is comprised almost solely of full-time partners of the Southern California Permanente Medical Group. There is a strong culture within the group of providing preventive care on the basis of evidence-based medicine, and compliance with suggestions to take action via a clinical reminder is high.

Another unique and useful aspect of using the EMR for this program is the ability to provide immediate feedback to the primary physician regarding follow-up for these patients. When a screening ultrasound detects an AAA, an “abnormal results” alert is triggered by the reading radiologist for the physician to review the study result. The report contains our AAA follow-up guidelines that provide the physician with immediate information on how to respond and schedule the appropriate follow-up. The ROSE provides a back-up system to verify that follow-up is occurring.

There are a number of weaknesses in the approach that we have taken that should be highlighted. These deficiencies were recognized at the time we began the screening program, but the philosophy was to rapidly implement a program that could be improved in the future rather than delaying implementation in order to design a perfect program. We felt this approach would allow increased detection of additional patients with AAAs in our system immediately. First, we elected to include only 65- to 75-year-old males with a history of smoking in the target population, excluding women, non-smokers, and patients with a positive family history. While this is consistent with USPSTF and AHA recommendations, others have elected or advocated a broader approach.11,21,22 In the interest of cost-effectiveness and to avoid overwhelming our imaging services, we chose to exclude patients from the screening program if they had an abdominal imaging study within the past 10 years. Neither the reports nor the studies themselves were reviewed to confirm the absence of an aneurysm. It is known that even when an AAA is reported in the results of an imaging study that the information is often not recorded in the patient’s chart, even when an EMR is in use. One study showed that 58% of aortic dilations noted on a computed tomography scan were not recorded in the chart within 3 months, and 29% were never recorded.23 Therefore, there are possibly some patients in our population that were excluded on the basis of imaging criteria who have aneurysms. Fortunately, natural language processing software is improving and is an adjunct that will allow review of those patient’s medical records in the future and help identify patients that may have been missed.

The AAA screening program that was instituted also did not include outreach to patients via mail, phone, or e-mail but instead was based on use of the clinical reminder during patient encounters. Therefore, patients who do not have any encounters with a medical practitioner are not presently offered screening in our program. This deficiency would be easily remediable in the future.

Recent reports have also shown that a small but significant number of patients who have aortic dilation but whose aortic diameters that do not meet our 3.0 cm threshold will be found to have AAA or even rupture when followed long-term. In the Multicentre Aneurysm Screening Study (MASS) study, a threshold of 3.0 cm was also used, and AAA ruptures in the “normal” aortic diameter group began to increase after 8 years of follow-up, with half of the ruptures occurring in patients who had aortic diameters between 2.5 and 2.9 at the time of initial screening.10
A meta-analysis of patients with aortic diameters of 2.5 to 2.9 cm in eight screening studies showed progression to 5.4 cm or greater in 26.2% of patients with 10 complete years of follow-up. Finally, in the Gloucestershire study, patients with aortic diameter ≥2.6 cm were included in the surveillance group, and over a 10-year period, 15% developed an AAA >5.4 cm. Interestingly, a decline in the overall incidence of AAAs and aortic diameter over the 20 years of the study was also noted. In KP Southern California, we have emphasized reporting and coding of members with aortic diameters of 2.5 to 2.9 cm as “aortic ectasia.” The presence of this code on the patient’s problem list serves as a reminder to the primary physician to be vigilant regarding risk-factor modification and follow-up, although we have not established a strict follow-up imaging schedule for this group of patients. Use of the EMR will allow us to re-screen this population in the future at an appropriate time interval (most likely 5 years) if it is determined to be warranted.

Finally, we did not have a strict policy for follow-up of the portion of the screening population whose ultrasound exams were non-diagnostic due to inability to image the aorta. Practitioners were encouraged to order a non-contrast computed tomography scan, but this order was not generated automatically.

In summary, in a large integrated health care system such as Kaiser Permanente, a universally deployed EMR allows for rapid development and institution of a screening program for AAAs. This experience demonstrates the efficacy and immediate yield of this program in identifying patients with previously undetected AAAs and reducing the number of unscreened patients in our members. Diagnosis of patients with small AAAs and aortic ectasia also facilitates implementation of cardiovascular risk-reduction strategies and discussion with patients for this segment of our population. We believe that others can implement similar screening programs, particularly as EMR deployment is increasing and more integrated systems are being created such as Accountable Care Organizations. Acknowledging that the decision to initiate our program with the weaknesses noted above has undoubtedly missed some AAAs, on the whole, it is likely that far more patients have been diagnosed with AAAs than would have otherwise been detected. Overall, this has the potential to reduce the morbidity and mortality associated with ruptured AAAs in our organization. An analysis of the impact of the program on AAA rupture rate is planned in the future. Finally, it should be re-emphasized that the system we have established is not a one-time or static approach; it can be modified on an ongoing basis by varying the parameters that trigger the “firing” of the BPA. Therefore, the opportunity exists to adjust future criteria for screening and follow-up to minimize risk of missing some patients with AAAs.

AUTHOR CONTRIBUTIONS
Conception and design: RH, AS, GW, RS, MK
Analysis and interpretation: RH, AS, GW, SV, RS, MK
Data collection: RH, AS, GW, SV

Writing the article: RH, AS, GW
Critical revision of the article: RH, AS, GW, RS, MK
Final approval of the article: RH, AS, GW, SV, RS, MK

Statistical analysis: Not applicable
Obtained funding: Not applicable
Overall responsibility: RH

REFERENCES
DISCUSSION

Dr Ronald L. Dalman (Stanford, Calif). Dr Hye and his collaborators in the San Diego-area Kaiser Permanente System have achieved the seemingly unachievable — through modest tinkering with their electronic medical record system, and a prodigious commitment of imaging resources, they have reduced the number of unscreened men at risk for early AAA-related death system-wide by more than 50% within 15 months. This quality improvement project was undertaken on their own initiative, on the basis of internal data suggesting an excessive rate of ruptured AAA, with buy-in from radiologists and other significant stakeholders. A truly remarkable achievement, Bob, for which you are to be rightly congratulated.

To place this accomplishment in its appropriate context, a few facets deserve further elaboration by the authors.

First, was it worth it? The manuscript notes that it is too early to determine whether the incidence of ruptured aneurysm will decline, or survival improve following emergent repair, as a result of more comprehensive compliance with screening guidelines. But, are there sufficient aneurysms in your population to justify this effort?

The yield of this screening program in this “high-risk” population was 1.3%, with only 0.3% of newly identified AAA > 4.0 cm. Apparently, there are far fewer AAs in your population than were expected at the outset. As noted recently by Frank Lederle, AAA-related death appears to be in steep decline in the last 20 years, potentially as a function of declining numbers of cigarettes smoked per capita by Americans since the 1970s, and it may well be that current screening guidelines were developed for an “epidemic” which no longer exists. Also, a recent report from the long-running Chichester screening study in the UK suggests that as many as 50% of AAA less than 3.5 cm in diameter do not enlarge further, at least until age 65 will never go on to develop clinically significant AAA disease, but does that same relationship hold true for younger patients? What is the risk of later enlargement when the diameter is 3.0 cm or less at age 55, particularly in active smokers?

Did the “best practice alert” system become activated for any patient visit, for any purpose, to any participating Kaiser facility (eg, pharmacy visit, or physical therapy appointment, etc)? Now that you have demonstrated feasibility within Kaiser generally, what barriers exist to extending this system beyond the San Diego area (eg, Northern California or Hawaii)?

In summary, committed physicians and professional colleagues in the San Diego Kaiser system have demonstrated that, through the miracle of modern information technology, dramatic improvements in process measure compliance can be rapidly achieved. Even though, at the outset, 50% of the at-risk population were already receiving appropriate care, vast improvement was still achievable through coordinated effort. Hopefully, this experience can inform the larger U.S. health system regarding potential best-practice approaches to guideline compliance. Thank you to the Program Committee for allowing me to review and discuss this fine paper, and congratulations again to Dr Hye and his colleagues on a remarkable achievement.

Dr Robert J. Hye. I want to thank Dr Dalman for his kind remarks and review of the manuscript. Before answering the questions, I want to emphasize that this project involved all of the KP facilities in Southern California and not just San Diego. Additionally, we did not think our AAA rupture rate was excessive so much as we felt that many were preventable and part of the mission of any health care system should be to minimize preventable deaths.

As you correctly point out, the million-dollar question is whether this screening program is “worth it.” Unfortunately, we don’t know yet, but our next project will be to determine that. The current program was implemented largely using existing personnel, so the major expense was related to the additional ultrasound studies. As you know, calculation of all the costs one needs to consider in the financial assessment is complicated.

The other aspect of this question is whether the yield of AAA is adequate to justify the program. Admittedly, the yield of aneurysms in our study is lower than that of most screening studies.
We do not have the data regarding current or recent smokers versus remote smokers. There is an aggressive smoking cessation program in KP SCAL and California has one of the lowest rates of current smokers in the United States, so it is entirely possible that most of our patients were remote smokers. Additionally, since one of our selection criteria was the lack of an abdominal imaging study within the past 10 years, the population selected for screening probably represents a healthier group in general having had fewer encounters for medical care. The yield may increase if we limited screening to recent or current smokers or used a higher pack-year threshold.

The question of changing the definition of AAA to a larger size is interesting. We have had internal discussions regarding how to manage the population with aortic ectasia and those with small aneurysms. As you point out, the Chichester study did show a relatively low rate of aneurysm expansion and suggested that follow-up scan intervals might be individualized. In the Gloucestershire study, although many patients with aortic diameters less than 3.5 cm did not enlarge in follow-up, 40% of patients with initial aortic diameters between 3 and 3.9 cm underwent elective repair within 10 years of screening. A recent meta-analysis also showed size progression to over 5.4 cm in 26% of patients with initial aortic diameters of 2.5 to 2.9 cm. I think it would be difficult to completely exclude patients with aortic diameters between 2.6 and 3.5 cm from follow-up at this point, although applying some age criteria may be reasonable. We need better data to determine the appropriate rescreening intervals and whether those intervals should be adjusted on the basis of age, aneurysm growth or continued smoking.

I am not sure how to identify women at-risk beyond adding additional factors such as family history or peripheral arterial disease. Women represented less than 20% of the patients with rupture in our internal review and have a lower prevalence of AAA, so we do not currently plan to extend screening to females.

We do not believe that access to care was an issue in our prevalence of ruptured AAA. The majority of patients who ruptured had undiagnosed AAA and only a few had known AAA with failed follow-up. Our organization does not mandate that patients have yearly exams, but elderly patients are encouraged to see their primary care physician regularly, particularly if they have cardiovascular risk factors.

The decision to use 10 years without an abdominal imaging study as a criteria for screening eligibility was made by consensus after careful consideration. We recognized that we might miss a few patients but felt that the yield of AAA in the group with prior imaging would be low. We also felt that the additional resources required if we were to review those patients’ studies could not be justified. As mentioned in the manuscript, use of Natural Language Processing software to review reports may be a way to add some additional certainty regarding that group.

The “best practice alert” was activated for any physician or physician extender visit at any KP SCAL facility. An order for a screening aortic ultrasound is entered by back office staff in the chart of an eligible patient and then signed by the physician. Since a signed physician order is required, extending the system to non-provider visits would require a mechanism to generate the order and obtain a signature. There are no real barriers to implementation of this system in other Kaiser regions, but Kaiser in Northern California has generally elected not to use “best practice alerts”. KP in Hawaii and the Pacific Northwest have screening programs in place with the latter using the BPA mechanism.

Thank you again for the thoughtful review and we look forward to examining the cost and clinical effectiveness of this program for a future presentation.