The Use of Appropriate Use Criteria Are Increasing,
But What Are Their Effects on Medical Care?

Running title: Dehmer et al.; The Use of AUC and their Effects on Medical Care

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The first Appropriate Use Criteria (AUC) for coronary revascularization was published in 2009 with an update published in 2012. A new version of the AUC for coronary revascularization is currently under development and will hopefully address some of the constructive criticisms directed at the earlier versions. The use of AUC is increasing and several other organizations have developed AUC for different procedures outside the cardiovascular arena. For example, orthopedic surgeons now have AUC for several of their common procedures, the American Academy of Dermatology has AUC for Mohs surgery, and recently AUC for placement of Foley catheters was published. With the increasing development, promotion and adoption of AUC it is reasonable to ask a critical question. What are the effects of AUC on the delivery of cardiovascular care? This is a fair question as the AUC are intended to address the rational use of coronary revascularization, provide a practical standard upon which to assess and understand variability and evaluate overall patterns of care regarding coronary revascularization.

The paper by Bradley and colleagues in this issue of Circulation provides some insight into that question. Using data from the Washington State Clinical Outcomes Assessment Program (COAP) they examined temporal trends in the number of PCI procedures performed, and specifically the number of PCIs rated as inappropriate. High performing hospitals were identified by a low or declining proportion of inappropriate PCIs or PCIs performed with insufficient pre-procedural information to allow the assessment of appropriateness. They showed that after the adoption of the COAP program there was an overall decline in the number of PCIs performed and specifically, a substantial decline in the number of PCIs for elective indications. Although there was a slight increase in the number of PCIs performed for unstable angina or NSTEMI during the same period, this increase was insufficient to explain the decline in elective PCIs. Therefore, the increase in PCIs for acute coronary syndromes was not felt to be operators...
simply learning the coding system and shifting the diagnosis. The decline in use of elective PCI was significantly larger following the onset of the statewide PCI appropriateness assessment with a modest increase in the proportion of elective PCIs classified as appropriate and a modest decrease in the proportion of inappropriate PCIs. Of note, the decline in the proportion of inappropriate PCI was limited to the tertile of hospitals with the largest decline in PCIs classified as inappropriate (25% in 2010 to 12% in 2013). This observation must be viewed within the context that the number of PCIs in the US has also declined in the same time period. Whether this is related to the overall adoption of the AUC for revascularization, AUC for diagnostic cardiac catheterization and AUC for stress imaging nationwide or other factors is unclear.

How should we view the findings by Bradley et al; specifically, are the AUC making an impact on clinical care? Compared with Clinical Practice Guidelines, the AUC documents are relatively new in the cardiovascular arena. Only recently have studies emerged showing the effects, potential benefits and limitations of AUC in cardiovascular care. Some of the more notable studies to date are summarized in the Table 1. In addition to the growing evidence base, another beneficial effect of the AUC is that they are readily adaptable for use as clinical decision support (CDS) tools. For both myocardial perfusion imaging and echocardiography such tools have been shown to increase the proportion of appropriate rated testing and decrease the proportion of inappropriate rated testing. Similar CDS tools exist for both diagnostic cardiac catheterization and coronary revascularization that run as web-based or smart phone applications, but their clinical use has not been evaluated to determine if these CDS tools alter the appropriateness classification of these procedures.

Other clinical benefits of the AUC have been demonstrated. Doukky et al, showed that when myocardial perfusion imaging was performed for appropriate indications it had a high
prognostic value in contrast to inappropriate test performance which was shown to lack effectiveness for risk stratification\(^\text{10}\). Moreover quality of life before and 1 year after revascularization, as assessed by the Seattle Angina Questionnaire and the EQ-5D, showed the greatest improvement compared with medical therapy when the revascularization was categorized as appropriate\(^\text{11}\).

Several studies have explored the association between procedure appropriateness ratings and the outcomes from coronary angiography or PCI. In a large sample derived from the National Cardiovascular Data Registry, there was no relationship between the proportion of inappropriate rated PCIs and in-hospital mortality, periprocedural bleeding, or medical therapy at discharge\(^\text{12}\). This led the authors to conclude that PCI appropriateness measures a different aspect of PCI quality than these 3 outcomes. Periprocedural bleeding is a function of vascular access, hemostasis and other clinical factors that place a particular patient at risk for bleeding. These factors exist irrespective of whether the PCI was rated appropriate or inappropriate so the lack of an association seems expected. Moreover, the major defining characteristics among inappropriate PCIs are a lack of medical therapy, no or mild symptoms or a low ischemic burden\(^\text{16}\). In-hospital mortality occurs more frequently in higher risk patients, thus the lack of association is also not surprising and potentially expected\(^\text{17}\). Mohareb et al, examined the relationship between the appropriateness rating of coronary angiography in patients with suspected stable ischemic heart disease and the proportion of patients subsequently found to have significant obstructive CAD\(^\text{14}\). Although more patients with appropriate indications had obstructive CAD and underwent revascularization, a substantial proportion of those with inappropriate or uncertain indications also had important coronary disease. The new terminology for “uncertain” is “may be appropriate” reflecting the fact that the procedure being
evaluated may be a reasonable and acceptable choice of the patient\(^{18}\). Similarly, the new term replacing “inappropriate” is “rarely appropriate” indicating that revascularization for a few patients in this category is still the best choice. Patients are classified as uncertain or may be appropriate because: a) there is insufficient clinical data to further characterize them into a different category, b) there are other clinical variables not considered in the AUC construct that can affect the clinician’s decision or c) this particular group of patients has not been well studied and thus the best therapy is uncertain. For example, there are few studies that specifically examine the clinical utility of revascularization in patients with chronic renal failure. In the study by Mohareb, 89% of the studies were either appropriate or uncertain, with the remainder (11%) considered inappropriate\(^{14}\). The authors also expressed concern that 7.1% of patients deemed inappropriate had important left main of 3 vessel CAD. However, further examination of their data shows that their entire inappropriate group was asymptomatic and either did not have a stress test or had a low risk stress test result. Many factors could explain this finding including limitations of the clinical history, exercise testing or interpretation of the angiogram. Finally, in a retrospective application of the AUC for revascularization, Ko et al, identified substantial underutilization and overutilization of coronary revascularization but significantly increased adverse outcomes (death or an acute coronary syndrome after 3 years) if an appropriate coronary revascularization was not performed\(^{13}\). This highlights the fact that the AUC were originally devised to address underuse as well as overuse of procedures\(^{19}\).

With this growing evidence base, the use of AUC as a mechanism to benchmark ordering patterns and assess variations in care has continued to gain attention especially among payers and the government. In March 2014, Congress passed the \textit{Protecting Access to Medicare Act of 2014} (H.R. 4302) that includes a provision requiring ordering professionals to consult with AUC...
through a Clinical Decision Support mechanism for all Medicare patients receiving advanced imaging (cardiac nuclear, computed tomography and magnetic resonance) starting in January 2017. This program will collect information about practice patterns but importantly will not tie payment to the appropriate use score for individual cases. This is an extremely important part of this legislation as some states and payers have started using the AUC to adjudicate payments, a function the AUC were never intended to perform. Rather the AUC were intended guide practice and prevent or reduce prior authorization mechanisms. Implementation of the AUC directive is one of the first steps in the transition Medicare will make over the next several years to pay for value instead of volume. Studies such as the one by Bradley and colleagues help the cardiovascular community further understand the potential role AUC will have on the delivery of cardiovascular care in the future. At present, the AUC are imperfect instruments, but will continue to be refined and mature as more knowledge about their use and limitations is produced.

**Conflict of Interest Disclosures:** None. The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

**References:**


11. Wijeysundera HC, Qiu F, Fefer P, Bennell MC, Austin PC, Ko DT. Association between appropriateness of coronary revascularization and quality of life in patients with stable ischemic


### Table 1. Summary of Appropriate Use Criteria Studies.

<table>
<thead>
<tr>
<th>Author</th>
<th>AUC Evaluated</th>
<th>Hypothesis/Purpose</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lin8</td>
<td>Imaging</td>
<td>Evaluated use of an AUC decision support tool for determining rates of appropriateness for noninvasive CAD imaging tests</td>
<td>Tool enabled rapid determination of test appropriateness for and was associated with increased and decreased testing for appropriate and inappropriate indications, respectively</td>
</tr>
<tr>
<td>Johnson9</td>
<td>Echocardiography</td>
<td>Quality improvement project to improve appropriate use of echo</td>
<td>Increase in appropriate and decrease in inappropriate echo ordering demonstrated</td>
</tr>
<tr>
<td>Doukky10</td>
<td>Myocardial Perfusion Imaging</td>
<td>Inappropriate use of SPECT MPI limits prognostic value</td>
<td>When appropriate, MPI has high prognostic value. Inappropriate use lacks effectiveness for risk stratification</td>
</tr>
<tr>
<td>Wijeysundera11</td>
<td>Coronary revascularization</td>
<td>Evaluated relationship between appropriateness and QOL</td>
<td>Patients who had appropriate revascularization derived the greatest improvement in QOL compared with medical therapy.</td>
</tr>
<tr>
<td>Bradley12</td>
<td>Coronary revascularization</td>
<td>Determine association between the appropriateness of the PCI and processes of care and post-procedural outcomes.</td>
<td>Inappropriate PCIs not associated with in-hospital mortality, bleeding, or medical therapy at discharge. PCI appropriateness measures aspects of hospital PCI quality that are independent of how well the procedure is performed.</td>
</tr>
<tr>
<td>Ko13</td>
<td>Coronary revascularization</td>
<td>Perform a population-based study to evaluate the association between appropriateness of coronary revascularization and longer-term outcomes.</td>
<td>Using the AUC substantial underutilization and overutilization of coronary revascularization was identified. Underutilization was associated with increased risks of adverse outcomes in patients with appropriate indications.</td>
</tr>
<tr>
<td>Mohareb14</td>
<td>Coronary angiography</td>
<td>Assessed validity of the AUC in predicting obstructive CAD in patients having elective coronary angiography for suspected stable IHD.</td>
<td>89% of studies rated appropriate or uncertain had obstructive CAD. 7% rated inappropriate had significant CAD.</td>
</tr>
</tbody>
</table>

AUC, appropriate use criteria; CAD, coronary artery disease; IHD, ischemic heart disease; MPI, myocardial perfusion imaging; QOL, quality of life; SPECT, single photon emission computed tomography; PCI, percutaneous coronary intervention.
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