Implantable Cardioverter-Defibrillators and Cardiac Resynchronization Therapy in Older Adults With Heart Failure

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BACKGROUND/OBJECTIVES: Implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy (CRT) are cardiac implantable electronic devices that may improve morbidity and mortality in select patients with heart failure. Although the benefits of these devices have been well defined, competing mortality risks, comorbid conditions, and frailty pose difficulty in determining risk-benefit trade-offs when these options are considered for older adults.

CONCLUSION: In this review, we focus on the benefit, risk, and use of ICD and CRT in older adults, particularly because the goals of care for many older adults include a shift away from life-prolonging interventions. Additionally, we discuss periprocedural risk, cost, and maintenance in older populations. Finally, we introduce a framework for helping clinicians and older adults make these challenging decisions collectively. **J Am Geriatr Soc 67:2193-2199, 2019.**

Key words: implantable defibrillators; cardiac resynchronization therapy; shared decision making; older adults

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In select patients with heart failure (HF), implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy (CRT) provide important therapeutic options to mitigate risk of sudden cardiac death and improve quality of life. Broadly, ICDs and CRT are permanent cardiac implantable electronic devices with intent to (1) monitor and treat for life-threatening heart rhythms in patients at risk for such rhythms (ICDs), (2) resynchronize cardiac contractility (CRT pacemaker [CRT-P]), or both (CRT defibrillator [CRT-D]). Both ICDs and CRT devices are composed of a generator, typically placed via a small surgical incision in the prepectoral chest region, that leads that course to cardiac chambers or coronary vessels via the vascular tree. Indeed, prior data show a steady increase in the median age at which device implantation is being pursued.[1,2] However, decision making for older patients with HF who may be candidates for device-based therapy remains particularly challenging. In this review, we look to focus on the risk-benefit trade-off associated with ICD and CRT use in older adults.

Competing mortality risks, comorbid conditions, and frailty create difficulty in application of clinical trial data to an older population, increasingly seen in clinical practice. We share the following clinical scenarios from our experience (Table 1).

BENEFIT OF ICD AND CRT THERAPIES

Landmark trials[3-5] evaluating patients with risk factors of sudden cardiac death but without prior episodes of life-threatening arrhythmias (ie, primary prevention) led to a dramatic, national increase in ICD use in the early 2000s. With the principal intent of detection and treatment of ventricular arrhythmias, prior to use for primary prevention, ICD implantation was typically reserved for those who have experienced such arrhythmias[6] (ie, secondary prevention). Although in patients with primary or secondary prevention indications, ICDs are critical in prevention of arrhythmic death, impact on quality of life has been assessed to a limited extent in these landmark trials. Compared to medical therapy, patients randomly assigned to ICDs had similar quality-of-life measures in the pivotal Sudden Cardiac Death in Heart Failure Trial (SCD-HeFT),[5] Antiarrhythmics versus implantable defibrillators trial (AVID),[6] and the Multicenter Automatic Defibrillator Implantation Trial II (MADIT II[4]).[7]

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Table 1. Clinical Scenarios Noted in Practice

Case no.	Age	Comorbid conditions	Reason for referral
1	An 81-year-old male with New York Heart Association Class II-III functional status	• Ischemic cardiomyopathy with an EF of 25% • Frailty • Osteoporosis • Diabetes • Chronic kidney disease	Consideration for primary prevention ICD
2	An 85-year-old female with New York Heart Association Class II-III functional status	• Nonischemic cardiomyopathy with an EF of 20% and LBBB with QRS duration of 150 ms • Frailty • COPD • Osteoporosis • Mild CKD	Consideration for ICD, CRT with pacing only, or CRT with capability for defibrillation therapy

Abbreviations: CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CRT, cardiac resynchronization therapy; EF, ejection fraction (by surface echocardiography); ICD, implantable cardioverter-defibrillator; LBBB, left bundle branch block.

Table 2. Indications for Consideration of ICD or CRT Implantation

Class	ICD (primary prevention for ICM/NICM)	CRT
Class I indications (indicated)	1. LV ejection fraction ≤35% due to prior MI in those who are at least 40 days post-MI and are NYHA functional class II or III	1. LV ejection fraction ≤35%, sinus rhythm, LBBB with QRS duration ≤150 ms, and NYHA class II or III or ambulatory 4 symptoms on GDMT
	2. LV ejection fraction ≤35% due to nonischemic dilated cardiomyopathy and NYHA class II or III	
	3. LV ejection fraction ≤30% due to prior MI in those who are at least 40 days post-MI and are NYHA functional class I	
Class IIA indications (can be useful)	1. ICD implantation is reasonable for patients with unexplained syncope, significant LV dysfunction, and nonischemic dilated cardiomyopathy	1. LV ejection fraction ≤35%, sinus rhythm, LBBB with QRS duration 120-149 ms, and NYHA class II or III or ambulatory IV symptoms on GDMT
		2. LV ejection fraction ≤35%, sinus rhythm, non-LBBB with QRS duration ≥150 ms, and NYHA class III or ambulatory IV symptoms on GDMT
		3. LV ejection fraction ≤35%, atrial fibrillation on GDMT if (*a*) AV nodal ablation or pharmacological rate control will allow near 100% ventricular pacing or (*b*) the patient requires ventricular pacing or otherwise meets CRT criteria
		4. LV ejection fraction ≤35% on GDMT in those who are undergoing new or replacement device placement with anticipated requirement of significant (>40%) ventricular pacing

Abbreviations: AV, atrioventricular; CRT, cardiac resynchronization therapy; GDMT, guideline-directed medical therapy; ICD, implantable cardioverter-defibrillator; ICM, ischemic cardiomyopathy; LBBB, left bundle branch block; LV, left ventricle; MI, myocardial infarction; NICM, non-ICM; NYHA, New York Heart Association.

In comparison, application of CRT in select patients, either in conjunction with defibrillation capability (CRT-D) or without (CRT-P), has consistently shown improvement in functional status, improvement in 6-minute walk time, reduction in HF-related hospitalizations, and improvement in quality of life.[8,9] However, patient selection remains challenging in predicting benefit from CRT, requiring collective and independent analysis of variables, such as: (1) QRS duration; (2) QRS morphology; (3) New York Heart Association (NYHA) functional class; (4) ejection fraction, as typically measured by surface echocardiography; (5) life expectancy; and (6) sinus or nonsinus rhythm, among others (Table 2). Accordingly, the 2012 American College of Cardiology/American Heart Association/Heart Rhythm Society update of the 2008 device-based therapy guidelines incorporated these variables in evaluation of those that may benefit from CRT.[10] Importantly, provider assessment and communication of likelihood of benefit from CRT is an important part of patient-provider decision making surrounding use of resynchronization therapy (Figure 1).

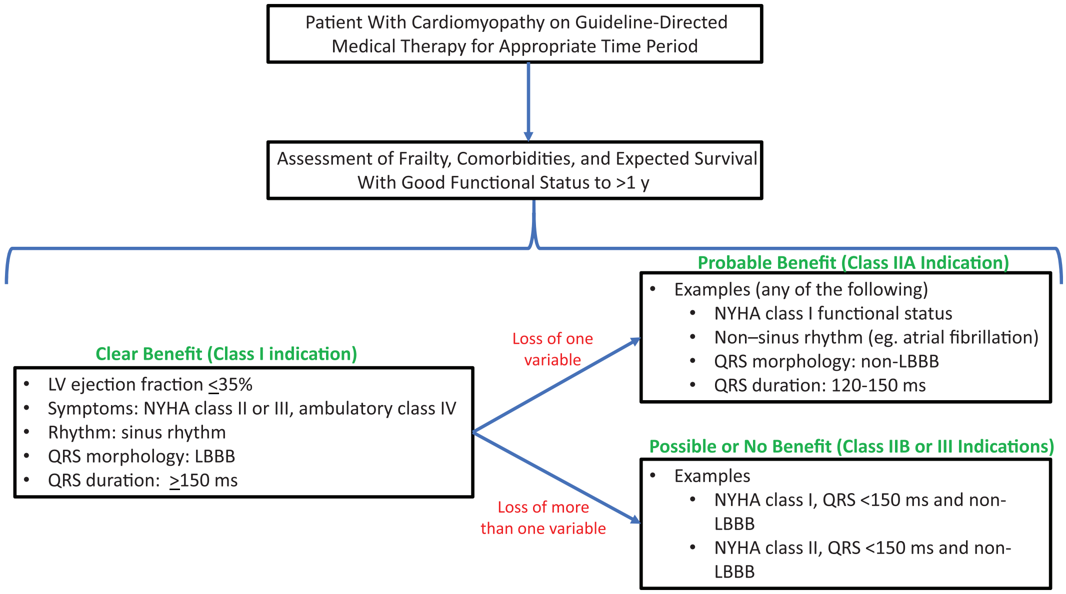

Figure 1. A simplified approach to initiating assessment for possible benefit from cardiac resynchronization therapy. LBBB indicates left bundle branch block; LV, left ventricular; NYHA, New York Heart Association.

ICD AND CRT USE IN OLDER POPULATIONS

Patient selection for CRT and ICD therapies has significant implications for an aging population in which the prevalence of HF is expected to increase by 46% by 2030, to an estimated 8 million persons.[11] HF currently affects nearly 10 of 1000 persons aged 65 years or older, and the risk of developing new HF continues well into advanced age (eg, an 80-year-old individual without HF still has a 20% chance of developing new HF in his/her remaining lifetime.[12] Significant consideration, therefore, must be given to how to use these therapies in older adults.

A critical guidance made in clinical practice guidelines for the management of ventricular arrhythmia is that “all recommendations related to ICDs require that meaningful survival of >1 year is expected; meaningful survival means that a patient has a reasonable quality of life and functional status.”[13] Similarly, HF guidelines recommend that “CRT is not indicated for patients whose comorbidities and/or frailty limit survival with good functional capacity to less than 1 year.” The challenge comes in identifying the patients with a “reasonable” or “good” functional status: as the guidelines acknowledge, the “range of uncertainty remains wide.”[14] This is especially true for older adults, in whom functional status and life expectancy may vary considerably between two “similar” patients of the same age.

Older patients represent a fraction of those enrolled in landmark primary prevention ICD trials. While only one trial excluded patients older than 80 years,[3] the average age in the therapeutic arms of primary prevention ICD trials was 63 years in MADIT,[3] 65 years in MADIT-II,[4] 58 years in the Defibrillators in Non-Ischemic Cardiomyopathy Treatment Evaluation (DEFINITE) trial,[15] 60 years in SCD-HeFT,[5] and 63 years in the Insulin Resistance Intervention After Stroke (IRIS) trial.[16] With one notable exception, prespecified subgroup analyses in each of these trials did not show a statistically significant benefit of ICD implantation among patients older than 65 years. Examined in aggregate, however, a systematic review of these trials did suggest a benefit to ICD implantation in older adults.[17] A meta-analysis of three major primary prevention trials came to a similar conclusion, although the researchers found a smaller magnitude of benefit to ICDs among patients older than 60 years.[18]

Large-scale analyses of the major clinical trials of CRT consistently demonstrate a significant mortality benefit in older patients older than 65 years.[8,9,19,20] Despite enrollment of predominantly younger patients in landmark trials evaluating CRT,[8,19,21] data show the proportion of devices including CRT increases with age strata,[19,22] with up to 40% of devices implanted in those older than 80 years including resynchronization capability. Retrospective substudies of randomized controlled trials[23,24] focusing on older adults have shown improvement in functional status and left ventricular dimensions by echocardiography.[23] Similarly, prospective data have shown that compared to younger patients, the benefit of resynchronization therapy translates to older populations (those aged ≥80 years) who show equivalent improvements in NYHA class, functional status, left ventricular ejection fraction, and left ventricular dimensions.[25] In further support of this finding, a large retrospective analysis of registry data from the United States suggests consistently lower mortality among patients receiving CRT therapy across all age groups, including more than 25 000 patients older than 75 years.[26]

Distinct from defibrillation capability, cardiac resynchronization has the added benefit of improving patients' quality of life and overall morbidity. Two prospective cohort studies have demonstrated that older patients experience similar benefits to younger patients in terms of quality of life, functional improvement, and echocardiographic remodeling.[27,28] Importantly, these benefits are tempered among frail older adults or those who perform poorly on a 6-minute walk test.[28,29] These findings may be particularly important to older persons focused on quality rather than quantity of remaining life.[30]

PROCEDURAL RISK AND DEVICE CARE IN OLDER POPULATIONS

Despite growing evidence confirming benefit of CRT in older patients, data regarding periprocedural and long-term complications are lacking. In all comers, large-scale analyses in the United States have shown rates of major complications (pericardial effusion, vascular injury, pneumothorax, hematoma, device infection) associated with CRT devices from 2003 to 2013 continue to be lower than 2%, despite implantation in older patients with more comorbidities over time.[31] Compared to younger cohorts, limited subanalyses and meta-analyses in older patients suggest a marginally higher rate of pulmonary injury (ie, pneumothorax) associated with CRT implantation.[31,32]

In comparison, observational data suggest that ICD complication rates are similar for older patients, regardless what age cutoff is used to define "older."[33,34] Whereas lead complications (dislodgment, fracture) predominate in the first 12 months after cardiovascular implantable electronic device (CIED) placement, issues arising in the years that follow are mainly related to the battery life of the CIED generator.[35] Although battery life may be longer with more recent devices, published estimates of generator longevity average 6 to 8 years for ICDs and 5 to 6 years for CRT devices,[36] necessitating one or several generator changes in the future.

In light of the aforementioned issues, patients are expected to participate in routine monitoring of their device's function at least every 6 months.[37] Remote monitoring systems, now available for every major device manufacturer, have made this more convenient for patients, but guidelines still recommend at least an annual in-person visit to a cardiologist or a cardiac electrophysiologist.[38] Such a visit serves, in part, to monitor for occult complications that can occur at any time over the lifetime of the device, such as infection and inappropriate device function. Inappropriate ICD shocks are not only associated with psychological morbidity[39] but also increased mortality.[40] Highlighting the importance of routine device maintenance, contemporary programming techniques and algorithms have decreased the annual rate of inappropriate shocks from 8% to 40% to 1% to 5%.[41] Although uncommon, device infections occur with an annual incidence of 2% to 5%.[42,43] Device-related infections can also be life threatening (5%-20% mortality) and, at times, can mandate complete system extraction regardless of whether the infection is localized to the generator pocket, bloodstream, or intracardiac structures.[44]

COST ASSOCIATED WITH ICD AND CRT THERAPIES IN OLDER POPULATIONS

Although cost-effectiveness considerations generally should not be the primary factor driving guideline-concordant clinical decisions to pursue device therapies, consideration of cost-effectiveness is reasonable in framing policy and population management with relatively expensive interventions, such as CIEDs. Overall, the costs of CIED therapy are significant and there has been some debate about whether ICD and CRT therapies in older adults are cost-effective.[45] Incremental cost-effectiveness ratios (ICERs) for CIED therapies based on clinical trial data have been estimated at $34 000 to $70 200 per quality-adjusted life year (QALY) for ICDs[46] and $19 600 to $43 000 per QALY for CRT devices.[47] Among patients who are candidates for both ICD and CRT, the cost of implanting a CRT-D over an ICD alone was $58 330 per QALY; this number improved substantially to $7320 per QALY when applied to patients with a left bundle branch block.

Importantly, the time horizon over which patients are estimated to benefit from CIED therapy has a sizeable impact on cost-effectiveness estimates. For example, applying the same clinical efficacy data to a 3-year, instead of 7-year, "benefit period," the ICER for ICDs jumps to $70 000 to $150 000 per QALY and for CRT to $32 000 to $100 000 per QALY. In other words, it is likely to be substantially more cost-effective to implant an ICD in an 85-year-old patient with a life expectancy of 7 years than it is to implant the same ICD in a 75-year-old patient with a life expectancy of 3 years. While the Centers for Medicare and Medicaid Studies' National Coverage Determination for ICDs makes no mention of cost or QALYs,[48] as cost becomes an increasingly important consideration in US healthcare, the time horizon over which these therapies are effective will become increasingly relevant.[49]

ASSESSING THE RISK-BENEFIT TRADE-OFF ASSOCIATED WITH ICD OR CRT

Indeed, personalized, patient-centered analysis of risk-benefit trade-offs associated with CIED use is the cornerstone of appropriate patient selection (Figure 2). In appropriately selected geriatric patients with HF, CRT may prove beneficial in improving quality of remaining life (CRT-P), extension of life (ICD), or a combination of both (CRT-D). In contrast to CRT, ICD therapy focuses solely on detection and treatment of life-threatening arrhythmias in those at increased risk of sudden cardiac death, with diminishing utility in advanced age given competing risks for noncardiac death.

Accordingly, multiple models estimating benefit and risk with ICD and CRT implantation have been designed and validated to assist with patient selection and shared decision making.[50-52] Interestingly, recent work in precision-predictive modeling in relation to CRT has shown variables associated with greater predictive benefit from CRT include: (1) age (greater expected benefit by each 10-year increment in age), (2) baseline quality of life (greater expected benefit for those with worse baseline HF quality-of-life measures), and (3) baseline QRS duration.[53]

For invasive procedures, such as ICD or CRT implantation, risk and benefit prediction tools may be especially important in supporting patient-clinician communication regarding personalized periprocedural and long-term risks, expected benefits, and device maintenance. In particular, they may prove useful in challenging "real-life" clinical scenarios, such as differentiating intent, risks, and expected benefit from distinct device-based therapies involving CRT (ie, CRT-D vs CRT-P). Importantly, supportive tools (ie, risk/benefit predictive models and decision-support instruments) may assist in simplifying the inherently convoluted risk-benefit discussion and focusing patient-clinician interaction to a patient-centered, values-concordant discussion.

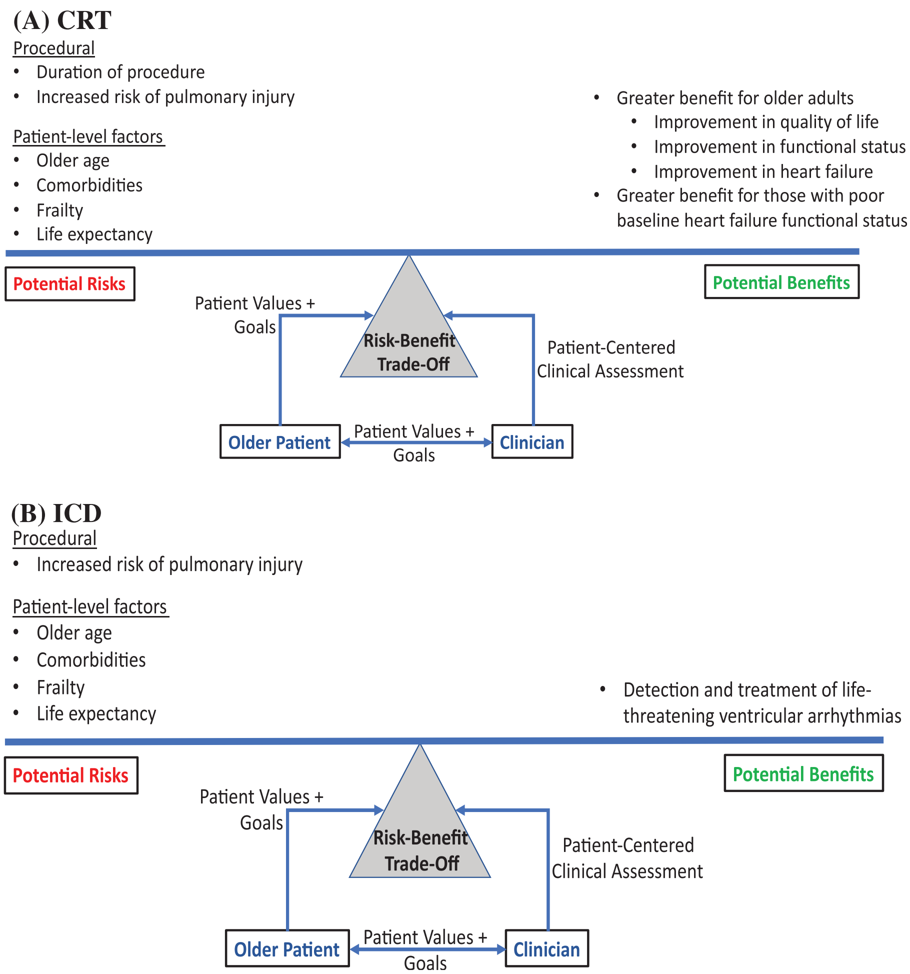

Figure 2. Schematic displaying analysis of risk-benefit trade-offs for cardiac resynchronization therapy (CRT; A) and implantable cardioverter-defibrillator (ICD; B) therapies focusing on older patients. [Color figure can be viewed at wileyonlinelibrary.com]

Revisiting case 1 presented in the introduction, this case represents an increasingly common clinical scenario of an older adult with multiple competing comorbidities referred for consideration of an ICD. A patient-centered discussion accounting for patient values in context of the primary intent of an ICD (to detect and treat life-threatening arrhythmias) may assist clinician-patient decision on proceeding with implantation. Given frailty, multiple competing comorbidities, and patient wishes, a shared decision to either proceed with ICD implantation or forgo the procedure may be entirely reasonable. In contrast, CRT therapy provides cardiac resynchronization with capability to significantly improve symptoms and morbidity in select older adults with HF. Case 2 presents a clinical scenario of an older adult who may benefit from CRT-D (cardiac resynchronization with defibrillation capability) or CRT-P (cardiac resynchronization only). Although with multiple similar comorbidities as the patient presented in case 1, CRT in the second case may be a reasonable therapy for both the physician and patient to consider given capability to significantly improve symptoms and functional status. Importantly, the shared decision to proceed with either CRT-P or CRT-D should be negotiated in the context of patient values, priorities, and goals for remaining life.

MOVING FORWARD, HOW TO HELP OLDER ADULTS MAKE THESE DECISIONS

Each decision hinges on whether the patient's goals align with accepting a device. In the case of ICDs, there is the hope of extending life, while foregoing the possibility of sudden death. Patients facing this decision may intuitively seize the opportunity to prevent sudden death, but many of the same patients also intuitively indicate that they would prefer to die peacefully in their sleep, which the ICD prevents.[54] In the case of CRT, the trade-off has much less to do with prolonging life than it does with improving quality of life and function; however, many patients considering CRT will also be offered a defibrillator along with it. In all cases, the decision should be driven by older adults' healthcare goals and preferences.[55]

Unfortunately, reports frequently highlight suboptimal practice with respect to patient education and inclusion in decision making.[56,57] Patients with ICDs frequently report never having had a conversation about periprocedural risks, expected benefits, or potential quality-of-life problems.[57] Studies of clinicians' perspectives identify guideline-based, rather than patient preference–based decision making.[58] An integrative review of studies exploring patients' perspectives highlighted a paternalistic approach to decision making.[59-61] As a consequence, patients generally overestimate the benefits and underestimate the risks of the therapies they are offered. Additionally, they are frequently uninformed about device deactivation at the end of life, a situation that can lead to unnecessary pain at the end of life, with patients receiving unnecessary shocks.[62-65]

Given these trade-offs, the most recent version of the Guidelines for the Prevention of Ventricular Arrhythmias and Sudden Cardiac Death recommends shared decision making for implantable defibrillators as a class 1 guideline.[13] Additionally, the Centers for Medicare and Medicaid recently mandated that a "formal shared decision-making encounter" must occur prior to implanting a primary prevention ICD.[66] Shared decision making, as defined by the National Quality Forum, "is a process of communication in which clinicians and patients work together to make optimal healthcare decisions that align with what matters most to patients." They further state that shared decision making requires three components: (1) unbiased medical evidence; (2) clinician expertise in communication and tailoring that evidence to an individual; and (3) patient values, goals, and informed preferences.

Decision aids are one evidence-based strategy to help clinicians and patients achieve a shared decision. A Cochrane review of 105 randomized trials demonstrated that patient decision aids improve knowledge, satisfaction, and patient/provider communication; increase patient involvement in decision making; and reduce patient decisional conflict and regret.[67] Our group has developed and piloted decision aids for patients with ICDs, which are currently being tested in larger trials.[68]

This article has discussed the evidence and outcomes of care associated with ICDs and CRTs in older adults. The challenge for a clinician caring for an older adult facing this decision is to explore whether the evidence applies to this individual patient based on his/her comorbidities and life expectancy and to explore the patient's values and goals. As in all care of older adults, this is in the service of assuring that the ultimate decision is grounded to both the clinical realities and the patients' health outcome goals.

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