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Assessing physical function and activity for survivors of a critical illness: A review of instruments

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Summary
Background: Functional outcomes and health-related quality of life are important measures for survivors of a critical illness. Studies have demonstrated debilitating physical effects for a significant proportion of surviving patients, particularly those with intensive care unit-acquired weakness. Contemporary practice changes include a focus on the continuum of critical illness, with less sedation and more physical activity including mobility while in ICU, and post-ICU and post-hospitalisation activities to support optimal recovery. How to best assess the physical function of patients at different phases of their recovery and rehabilitation is therefore important.
Purpose: This narrative review paper examined observational and functional assessment instruments used for assessing patients across the in-ICU, post-ICU and post-hospital continuum of critical illness.
Methods: Relevant papers were identified from a search of bibliographic databases and a review of the reference list of selected articles. The clinimetric properties of physical function and HRQOL measures and their relevance and utility in ICU were reported in narrative format.
Findings: The review highlighted many different instruments used to measure function in survivors of ICU including muscle strength testing, functional tests and walk tests, and patient centred outcomes such as health related quality of life. In general, the sensitivity and validity of these instruments for use with survivors of a critical illness has not yet been established.

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Conclusion: Based on findings from the review, screening of patients using reliable and valid instruments for ICU patients is recommended to inform both practice and future studies of interventions aimed at improving recovery and rehabilitation.

Introduction

Examining functional outcomes and health-related quality of life (HRQOL) for survivors of a critical illness is a contemporary area of interest for clinicians and researchers as mortality rates stabilise. With survival rates of 89% at hospital discharge[1] but delayed functional recovery evident from reviews of observational studies internationally,[2–4] practice initiatives to improve the recovery trajectory for a patient's 'continuum of critical illness'[5] are now being explored. This current view of an episode of critical illness as a continuum, commences with acute clinical deterioration, a period of treatment and care in the intensive care unit (ICU), and continues after ICU and hospital discharge until the patient's risk of late sequelae has returned to the baseline risk of a similar individual who has not incurred a critical illness.[5]

Delays in physical recovery have prompted a focus on rehabilitation strategies. Current evidence suggests that intensive care unit-acquired weakness (ICU-AW) syndrome results from a combination of the presenting illness (commonly sepsis), treatments and bed rest.[6,7] The term ICU-AW was developed to encompass critical illness myopathy (CIM), polyneuropathy (CIP) and neuromyopathy (CINM), and reflects muscle wasting and functional weakness in patients with a critical illness who have no other plausible aetiology.[8] With changes in practice to less sedation and more physical activity including mobility while in ICU,[9] and a focus on the continuum of critical illness to post-ICU and post-hospitalisation support for optimal recovery, there is a need to explore how to best assess the physical function and HRQOL of these patients at different phases of their recovery and rehabilitation.

Search methods

This narrative review examined the current evidence base for assessing physical function, mobility, health-related quality of life (HRQOL) and utility measures in patients with a critical illness, focusing on the common instruments used during in-ICU, post-ICU and post-hospital testing. Specific functional outcome measures used in ICU research were retrieved using the bibliographic databases PubMed and CINAHL, with additional sources identified from the reference list of selected articles. Search results were filtered for English-language. The clinimetric properties of physical function and HRQOL measures and their relevance and utility in ICU were reported in narrative format.

Findings

Search results are discussed using the following themes: functional tests, walk tests, strength tests, and HRQOL. Utility measures are also discussed within the scope of this topic.

Functional tests

Tests of functional status assess Activities of Daily Living (ADL), either as a self-report or during observation. Assessment of both upper and lower limb function provide an advantage over walk tests if the outcome measurement relates to specific functional tasks requiring upper limb use. Tests that assess functional status and are relevant for patients across their continuum of critical illness[5] include the Barthel Index (BI),[10] Functional Independence Measure (FIM),[11] the Physical Function in ICU Test (PFIT),[12] and Glittre ADL Test,[13] (see Table 1). The FIM was identified as providing a better measure of disability in medical rehabilitation cohorts when compared to the BI and other instruments.[14] The Glittre ADL Test[13] has been used in assessing patients with chronic obstructive pulmonary disease (COPD) and may have utility in assessing recovery and function in post-ICU patients, but this has not yet been evaluated in a research setting.

Only the PFIT was developed specifically for an ICU patient cohort; others were developed for other clinical specialities, primarily medical rehabilitation and aged care, however the BI and FIM have been used to assess survivors of a critical illness.[15] The FIM has been modified in more recent ICU research,[16] where only the specific aspects of function relevant to patients in ICU were examined

Table 1 Summary of common functional and walk tests applicable for assessing survivors of a critical illness.

Instrument	Description	Interpretation	Comments
Functional tests			
Physical Function ICU Test (PFIT)[12]	4 domains once patient able to sit out of bed: sit to stand, marching on the spot, shoulder flexion, muscle strength[e]	No total score calculated; enables prescription of activities based on results	Inter-rater reliability (ICC > 0.99 for all domains); responsiveness ($p = 0.02$—0.005);[12] intra-rater reliability: participants unable to repeat test because of fatigue
Barthel Index (BI)[100,97]	10 ADLs[a] measured on a 0—2 scale	Dependence: total = 0—4; severe = 5—12; moderate = 6—18; slight = 19; independent = 20	Used to assess patients in the post-ICU period[24]
Functional Independent Measure (FIM)[11]	18 ADLs in motor and cognitive themes[b]; 7-point ordinal scales; performed by a multi-disciplinary team over 72-hour period	Score range 18—126 (fully dependent—functional independence)	Acceptable levels of reliability and validity[14]; possible ceiling effects, particularly in outpatient settings[98]
Functional Ambulation Categories (FAC)[99]	6-point ordinal scale[c] assessing ambulation	Descriptive categories reflect function	Can be used to assess progress in walking in ICU cohort
Glittre ADL Test[13]	5 laps of a 10-metre walk with steps and carrying, lifting and bending activities[d]	Time-measurement; 4—5 min for in-patient pulmonary rehabilitation; ADL-time associated with disease severity[13]	Responsive to intervention[13]; used for patients with COPD, but not currently with survivors of a critical illness
Walk tests			
Six Minute Walk Test (6MWT)[18]	Distance walked in six minutes on a 30 m flat track or circuit. Requires the person to walk as far as possible in the six minutes. Standardised encouragement provided each minute. Rests permitted but rest time is included in the six minute period. Heart rate and oxygen saturation should be measured during the test.	The minimum important difference for the 6MWT based on changes following pulmonary rehabilitation has been variously reported as 10% or 35 m (95%CI 30—42)[100] and 14% or 25 m (95%CI 20—61)[101]	Reflects functional capacity in respiratory or cardiac diseases
Incremental Shuttle Walk Test (ISWT)[28]	Participants walk round a 10 m track (1 shuttle) in time with audio prompts. Walking speed increases each minute; 12 levels of speed (0.5—2.37 m/s). Number of shuttles and distance walked recorded. Heart rate and oxygen saturation should be measured during the test.	The minimum clinically important improvement in ISWT after pulmonary rehabilitation in COPD is reported as 47.5 m (95% CI 38.6—56.5)[30]	Used to assess patients in the post-ICU period[102]
Timed Up and Go (TUG)[31]	Stand from sitting in a chair, walk 3 m at regular pace and return to sit in the chair	Normal $\leq$10 s; good mobility, independent $\leq$20 s; requires supervision/walk aid = 21—30 s	Used to assess patients in the post-ICU period[102]

ICC: intra-class coefficients.

[a] Barthel Activities of Daily Living: feeding; moving from wheelchair to bed and return; grooming; toilet transfer; bathing; walking on level surface; propelling a wheelchair; ascending or descending stairs; dressing and undressing; controlling bowels; controlling bladder.

[b] FIM themes/items: 13 motor items covering personal care, sphincter control, mobility, locomotion; 5 cognitive items covering communication and social cognition.

[c] FAC categories: 0 = unable to walk or requires $\geq$2 people; 1 = continuous firm support from 1 person to walk; 2 = continuous or intermittent support from 1 person; 3 = verbal supervision or stand-by help (without physical contact) from 1 person; 4 = walk independently on level ground; requires help on stairs, slopes, uneven surfaces; 5 = walk independently anywhere.

[d] Glittre test: stand from seated position with a back pack (2.5 kg for women; 5.0 kg for men), walk 10 m including interposed two-step staircase to two shelves at shoulder and waist height; move 3 $\times$ 1 kg cartons one by one from the top shelf to the bottom shelf to the floor, then back to the bottom shelf then the top shelf; then walk return over the stairs and sit in the chair and then repeat (5 laps in total).

[e] PFIT activities: sit to stand with assistance (number of 0—3 people); marching on spot (MOS) (time, steps and steps/minute (cadence) recorded); bilateral shoulder flexion (through available range) (time, repetitions and cadence); muscle strength testing (Oxford scale 0—5) for knee extension and shoulder flexion.

Table 2 Responsiveness of the PFIT before and after weaning from mechanical ventilation.[12]

Domain	Mean difference before and after weaning	95% CI	*P* value
Marching on the spot			
Steps	+86.3	15.8—156.8	0.02
Seconds	+56	5.2—102.8	0.03
Cadence	+25.4	−1.7 to 50.3	0.04
Shoulder flexion			
Reps	+8	0.5—25.4	0.02
Seconds	+5.5		
Sit to stand	2 or less people		0.007
Muscle strength	+2 strength grades		0.005

separately. The Functional Status Score for the ICU (FSS-ICU) was further modified after the validity and reliability were assessed. These papers demonstrate that functional tests as they currently exist are not transferrable to ICU populations but that investigators are interested in exploring the clinimetrics of modified or alternative measures.[16]

Physical function in ICU test (PFIT)

The PFIT[12] was recently developed in Australia as a sub-maximal exercise test to be both an outcome measure and from which exercise can also be prescribed. It was specifically developed for patients in ICU who were unable to mobilise away from their bedside. The PFIT has four domains that reflect clinically important aspects of physical function that are likely to be responsive to training (Table 1) and was based on interventions that physiotherapists reportedly used during rehabilitation in ICU to assess endurance, muscle strength, exercise capacity and functional ability.[17] Performance of the PFIT involves sitting the patient out of bed in a chair. After a practice of sitting to standing, the test is administered using standardised instructions in the order of tasks presented in Table 1. Exercise training for each domain can be prescribed based on the PFIT results, e.g. marching on the spot 70—80% of the time achieved in the initial PFIT assessment.

The reliability and responsiveness of the PFIT was investigated in a small cohort of ventilated patients ($n = 12$). Responsiveness was assessed prior to and following weaning from mechanical ventilation with a mean time difference of six days between tests. All domains of strength, function and endurance showed improvement (Table 2). Validity testing of the PFIT remains a challenge, as there is no gold standard for measurement of exercise capacity in the critically ill population. Ongoing research involves the development of a total test score for the four domains of the PFIT, determining the predictive ability of the score and correlation with other functional outcome measures such as the Six Minute Walk Test and the Timed Up and Go test which are described below.

Walk tests

While the walk tests used in rehabilitation practice are commonly performed as sub-maximal tests, in debilitated patients they can act as maximal tests; this may be the case for recovering critically ill patients during initial and early assessment of mobility. The most common and relevant walk tests in this context are the six-minute walk test (6MWT), the Incremental Shuttle Walk Test (ISWT), and the Timed Up and Go (TUG).

Six-minute walk test (6MWT)

The 6MWT is a common measure of functional exercise capacity performed as a self-paced test in which the patient walks as far as possible in six minutes on a flat track. The recommended shuttle track length is 30 m, although track lengths of 20—50 m and circular tracks have been used.[18] It is recommended that two walk tests be performed at each assessment to account for a learning effect.[18] A significant increase in the distance walked in a second test has been demonstrated in chronic obstructive pulmonary disease (COPD),[19] chronic heart failure (CHF)[20] and in patients recovering from a critical illness.[21]

Practical guidance for performing the 6MWT is available.[22] Standardised encouragement is given each minute by the assessor. A patient can stop and rest, but this time is counted within the six minutes.[18] The ability for a rest makes the 6MWT a useful measure, as the same test can be used across the continuum from critical illness to recovery. However, for patients who reach high levels of physical performance after an ICU admission, stride length and speed may limit the distance walked resulting in a 'ceiling effect'.[23] In contrast, very

disabled patients in ICU or after ICU-discharge may not walk at all resulting in a 'floor effect'. For example, almost 40% of patients were not able to walk or required 2 or more assistants, 4 days after ICU-discharge in a Dutch observational study ($n = 69$).[24]

The 6MWT has been used to evaluate recovery from a critical illness post-ICU discharge.[25,26] The most important determinants of walk distance in the 12 months following ICU discharge were identified as the use of systemic corticosteroid treatment during ICU, the presence of illness acquired in ICU, and the rate of resolution of lung injury and multi-organ dysfunction during ICU admission.[26]

The 6MWT correlated strongly with walking time ($r = 0.76$) and walking intensity ($r = 0.62$) in daily life in patients with COPD[27] and moderately with self-reported physical function (PF of the SF-36) in patients recovering from a critical illness ($r = 0.59$).[21]

Incremental shuttle walk test (ISWT)

The ISWT is an externally paced walking test in which the patient walks around two cones placed 9 m apart, giving a total track length of 10 m.[28] The initial walking speed is very slow and work rate (i.e. velocity) increases each minute. The test continues until the participant indicates the need to stop or can no longer keep up with the external auditory pacing. The ISWT has been validated in people with COPD.[28] Practical guidance on performing the ISWT is available.[22] The ICU environment is likely to render the ISWT impractical due to the need for a 10 m track, auditory pacing and turning around cones while attached to equipment. As well, patients need adequate cognitive function to comprehend the test requirements. However, in the immediate post-ICU environment the ISWT could be considered for the assessment of exercise capacity as the test has reflected peak exercise capacity in people with moderate to severe COPD[29] and is responsive to change.[30]

Timed up and go (TUG)

The TUG test was designed as a measure of mobility and gait performance[31] and was modified from an earlier test, the Get Up and Go Test. The TUG measures how quickly a person can rise from a standardised seated position, walk 3 m, turn around, walk back to the chair and sit down. Performance is measured using a stopwatch, requires little equipment to perform and therefore has high clinical utility. One of the advantages of the TUG test is that normative values exist for comparison (Table 1)[32]; completion within 10 s is considered normal mobility. The time score correlates with a log transformed score of the Barthel Index ($r = -0.78$).[31]

Strength tests

Testing of muscle strength in upper and lower limbs is widely used by clinicians to assess patients with neuromuscular deficits.[33] Muscle strength can be measured quantitatively using dynamometry or as a clinical assessment by manual muscle testing (MMT).[34] MMT has been selected as the technique to assess for ICU-AW because of its ease of use and clinical utility.[8] Dynamometry is also limited in severe muscle weakness when movement cannot be performed against resistance.[34]

Muscle strength can be assessed either statically (isometric contraction) or through range of movement with and without resistance. Both methods have been reliable and sensitive to change in non-critically ill populations.[35,36] However the levels of agreement between isometric and through range muscle strength testing has not been clearly established.

Muscle strength testing

Clinical assessment of muscle strength has been commonly described using a six-point ordinal scale (grades 0–5), with variations including the Oxford, Kendall and Medical Research Council (MRC) scales,[37] and one using narrative descriptions for levels of muscle contraction (normal, good, fair, poor, and trace or zero).[38] While these scales use differing symbols they are essentially based on similar principles: the presence or absence of gravity as a resistance, the arc of movement and the external/manual resistance applied to oppose a movement. Differences between scales include the position of testing, the stabilisation of surrounding structures, the level of resistance applied and the extent of sub-divisions between each strength grade.[33]

The MRC scale has been routinely used in critical care research to screen for muscle weakness.[39–41] This scale classifies muscle contraction as a 0–5 point ordinal scale[42]: 0 = no muscle contraction; 1 = flicker or trace of muscle contraction; 2 = active movement with gravity eliminated; 3 = reduced power but active movement against gravity; 4 = reduced power but active movement against gravity and resistance; and 5 = normal power against full resistance.[43]

Assessment of six muscle groups bilaterally for strength and symmetry (upper limb – shoulder abduction, elbow flexion, and wrist extensors; lower limb – hip flexion, knee extension, and ankle dorsiflexion)[44] has been used for the diagnosis of

ICU-AW. Patients are assessed seven days following awakening; a score of <48/60 (<4 in all testable muscle groups) indicates weakness associated with increased mortality and morbidity. There is however some conflicting evidence regarding the reliability of performing MMT in critically ill patients.[45] In addition, low rates of patients able to perform MMT while in ICU are reported due to the effects of sedation and the presence of delirium.[45] Despite these limitations MMT remains the suggested standard tool to diagnose ICU-AW.[44–46]

Further questions however remain in relation to testing. Unlike other methods of testing and grading muscle strength,[38,47] the MRC scale does not account for the range of motion through which the movement is performed, or the level of resistance applied. This leads to potential discrepancies in the method of measurement. While some scales advocate 'through range muscle strength assessment', the MRC scale does not clearly state whether muscle tests should be performed through range or as an isometric contraction. Also, while reliability has been established for both methods of strength assessment in non-critically ill populations, there are no data recording levels of agreement for the different approaches. Recent publications regarding the reliability of this form of testing do not describe the actual method of measurement, nor the joint angle at which the measurement of isometric force is made.[45,46] A consensus on methodology of strength testing is therefore required given that MMT using the MRC scale is currently the preferred screening or diagnostic tool for the presence of ICU-AW.

Hand held dynamometry

Hand held dynamometer (HHD) manual muscle test is a common measurement of strength and has been used in many different patient populations including cancer, COPD and elderly women.[32,48,49] Maximal contraction of the muscle group to be tested is encouraged while the operator resists the movement by holding the HHD in an appropriate position. The starting position of the person/movement and point of joint range of application are important factors in reproducibility and achieving a valid test. Measurements of shoulder abduction, knee extension and ankle dorsi-flexion have been reported, with responsiveness to change evident over time or post-exercise intervention.[32] HHD has demonstrated good intra-rater and inter-rater reliability for the measurement of shoulder strength, quadriceps and ankle dorsi-flexion[50,51] with trained physiotherapists. Quadriceps strength may be underestimated by HHD if the ability of the tester to resist knee extension is not adequate.

Hand-grip strength is a subset of HHD and enables measurement of force using a calibrated device for patients who are conscious and cooperative. Dynamometry is a reliable, rapid and simple alternative to comprehensive MMT assessment,[44] and may be a surrogate for global strength.[8] Normative data are available.[52–54]

Health-related quality of life (HRQOL)

Quality of life is a broad concept that incorporates all aspects of an individual's existence. Health-related quality of life (HRQOL) is a subset relating to the health domain of that existence, and is now viewed as an important patient-centred health outcome for survivors of a critical illness. Several review papers have identified the commonly used generic HRQOL instruments, and discussed their features and limitations.[2–5,55,56] These instruments are described here in relation to their assessment of physical function (see Table 3).These self-report HRQOL instruments can be administered in person, by phone or by mail and can be completed by the patient or a proxy (significant other). Proxy completion on behalf of the patient may be necessary in many instances in critical care where the patient is unable to respond (e.g. sedated, agitated, and cognitively impaired). A person most able to replicate the patient perspective is needed to provide substitute judgment about HRQOL.[57] The use of proxies appears sensible, as the critical illness itself may influence a patient's recollection of their pre-admission health status. Use of proxies may however not accurately estimate HRQOL, with several conflicting reports regarding proxy estimations published.[58–61]

Retrospective completion of pre-illness/baseline HRQOL information is often necessary in the critical care setting,[62] with pre-morbid HRQOL an important determinant of HRQOL after ICU.[3,63] Apart from proxy completion, this is commonly the only method to obtain these data. The baseline response and further completion of HRQOL instruments after ICU discharge can be affected by recall bias and response shift[64]; the latter is when patients change their value and perceptions of HRQOL after their illness.[64] Response shift measurement has not been undertaken with critical care patients to date.[65] These measurement issues related to HRQOL therefore need to be considered when reading and interpreting data in this area of critical care practice.

Some instruments are also multi-attribute utility instruments (MAU); e.g. AQoL, EuroQol 5D. Utility measures are based on patient preferences for a particular health state, and provide a single

Table 3 Summary of generic HRQOL instruments used for patients following a critical illness (adapted from[103]).

Instrument	Items; domains/concepts examined
Medical outcomes study (SF-36)[74,104]	36 items in 8 domains; physical: functioning, role limitations, pain, general health; mental: vitality, social, role limitations, mental health; health transition; variable response levels (2—5); Mental and Physical Component Summary calculated from domains
Assessment of quality of life (AQoL)[67]	15 items in 5 domains: illness (3 items); independent living (3 items); physical senses (3 items); social relationships (3 items); psychological well-being (3 items); 4 response levels; measured on a scale from 0.04 (state worse than death) to 1.00 (full health) where 0.0 is death equivalent; enables cost-utility analysis
15D[92,105]	15 items/domains: mobility, vision, hearing, breathing, sleeping, eating, speech, elimination, usual activities, mental function, discomfort, distress, depression, vitality, and sexual activity; 5-point ordinal scale (1 = full function; 5 = minimal/no function)
EuroQol 5D[68,92,106]	Adapted from 15D; 5 items: mobility, self-care, usual activities, pain/discomfort, anxiety/depression; 3 response levels; cost-utility index calculated
Nottingham Health Profile (NHP)[69]	45 items; experience: energy, pain, emotional reactions, sleep, social isolation, physical mobility; daily life: employment, household work, relationships, home life, sex, hobbies, and holidays
Quality of life — Italian (QOL — IT)[70]	5 items: physical activity; social life; perceived quality of life; oral communication; functional limitation; varied response levels (4—7)
Quality of life — Spanish (QOL — SP)[71]	15 items: basic physiological activities (4 items); normal daily activities (8 items); emotional state (3 items)
Perceived quality of life (PQOL)[72]	11 items on satisfaction with: bodily health; ability to think/remember; happiness; contact with family and friends; contribution to the community; activities outside work; whether income meets needs; respect from others; meaning and purpose of life; working/not working/retirement; each scored on 0—100 scale
Sickness impact profile (SIP)[73,107]	68 item short-version/136 items in 6 domains; physical: body movement, mobility, ambulation; psychosocial: intellectual, social interaction, emotional behaviour, communication; sleep and rest; daily work; household; leisure and recreation

summary score of outcome. Utility measures are particularly important when there are both mortality and morbidity effects and some integration of them is required, as may be the case in ICU. The conventional scale in which the state of being dead (the lack of health status) is assigned a score of 0.00 and perfect health is assigned a score of 1.00 provides a framework for the integration of mortality and morbidity. Utility scores are useful as measures of outcome and as 'inputs' in economic evaluations.[66]

The most common instrument used to measure HRQOL is the Short-Form 36 (SF-36); of 53 studies reviewed, 55% used SF-36[4] — see below. Also described is the AQoL, an Australian developed instrument,[67] and the EuroQol (EQ-5D),[68] used in 21% of studies in the above review.[4] Other instruments listed in Table 3 are mostly used in specific countries,[69—71] or are older and now less favoured in relation to more recently developed instruments.[72,73]

Short-form general health survey (SF-36)

The Medical Outcomes Study 36-item SF-36 health survey is a commonly used and well-validated instrument in many different disease populations.[74] The 36-item instrument has been widely used[26,59,75—80] and recommended in critical illness.[5,81] Benefits of using SF-36 include published national and international normative data,[74,82—85] and the minimal important difference (MID) transformed domain scores are reported to be $\geq$5 points[3,74] but range as high as 10—25 points in SF-36 Version 2.[86] Reporting using norm based scores is recommended, where mean $\pm$ SD is 50 $\pm$ 10 for each domain. The MID for SF-36 norm based scores has been reported to be 2 points for domain scores <40 and 3 points for domain scores >40.[74] The SF-36 has demonstrated reliability, validity and responsiveness,[87] in critical illness populations.

A further feature is that a utility measure can be derived from the SF-36, using 11 of the items from seven domains, called the SF6D. This version

has not however yet been validated in the critical illness population. One limitation in this setting is that SF-36 cannot account for a patient who is deceased, and missing data therefore becomes an issue in analysis and bias may be increased.

Assessment of quality of life (AQoL)
The AQoL is a generic MAU instrument designed to evaluate the cost-effectiveness of healthcare intervention by directly calculating utility scores.[67] As a HRQOL, the AQoL also allows measurement of health domains similar to the SF-36 (Table 3), and is validated in different patient groups[88,89] but not in the critical care setting to date. Utility scores range from 1.00 (best QOL state) to −0.04 (worst QOL state) where 0.00 is a death-equivalent state. Normative Australian AQoL data are available, and the MID for the AQoL is 0.06 points.[90] A newly developed shortened version is also now available — The AQoL 8,[91] although use in ICU populations has not yet been reported.

EuroQol 5D
The EuroQol 5D (EQ-5D)[68,106] was developed from the 15D Health Survey[105] (Table 3), and similar to the AQoL is both a HRQOL and an MAU instrument. While a more brief instrument, a recent comparison demonstrated that the longer 15D instrument was more sensitive to clinically important differences in health status than EQ-5D for survivors of a critical illness.[92] A previous study had demonstrated more sensitivity with SF-36 than 15D during recovery after cardiac surgery[93] and critical illness.[59]

Economic evaluation

The use of MAU instruments enables an economic evaluation to be conducted; measuring the cost effectiveness of an intervention is now an important consideration in health care decision-making globally. Increasing cost pressures are due to advances in medical technology leading to increased demand for services; the aging population and population growth generally.[94] The basic premise of health care economic evaluation is that resources available for health care are limited, so choices have to be made regarding which services are funded. Within this framework, there are three key concepts underlying economic evaluation: It defines inputs and outputs, described as *costs and consequence*; making choices between options; and comparing programs using transparent criteria.

Economic evaluations are usually undertaken from one of three perspectives[95]: (1) the health service perspective is where only the costs of providing a health service are considered. (2) The patient perspective includes both health service and patient costs; and (3) the societal perspective includes all costs (e.g. a cost utility or cost-benefit analysis). This last perspective is recommended[96] as it is the most comprehensive. In this analysis the patient outcome is measured using a MAU. The utility value (0—1) can be used to calculate quality adjusted life years (QALYs), an outcome measure that accounts for both the quantity and the quality of the extra life provided by the healthcare intervention being investigated. The utility value of a health state is multiplied by the length of time spent in that health state — one year of perfect health (utility value of 1) equals one QALY. For example if a person went from a HRQoL state of 0.5 to 1.0, and maintained this for 2 years, the QALY gain would be 1.00 (0.50×2.00).

One of the most useful aspects of QALYs is that they allow the 'value for money' provided by different interventions to be measured in a common unit — 'cost per QALY'. This can provide information on the comparative effectiveness of interventions within the same disease area and the relative effectiveness of interventions from different therapy areas. Ideally, cost effective programs indicate that there is a good probability of generating a QALY for a relatively low cost.

Most health care professionals undertaking research now include some type of economic measure of an intervention program. However, economic evaluations can be complex and require high levels of data collection. A Health Economist is recommended to guide this process and assist with analysis and interpretation of results.

Discussion

This review has highlighted a number of practice issues requiring consideration as we collectively aim to improve the recovery for survivors of a critical illness. Despite potential reliability and methodological issues, the assessment of muscle strength using the MRC scale in ICU remains the diagnostic technique of choice to screen for the presence of ICU-AW. While consensus panels have been developing definitions and guidelines for the clinical diagnosis of ICU-AW,[41] related fundamental assessment issues on the standardised procedure for manual muscle testing with the MRC scale has had little evaluation.

There are currently also many different functional outcomes used in ICU research. As yet we have not confirmed which are the most valid and sensitive to use in different ICU populations. It is probable that some tests have ceiling effects (e.g.

FIM) and others will have floor effects early in recovery for this heterogeneous population (e.g. 6MWT). While SF-36 remains the most commonly used instrument for assessing HRQOL in a variety of critically ill patient groups, further work continues in establishing the most appropriate instrument for use in critical care cohorts.

Some limitations of this narrative review are noted. While this review has focused on physical assessment, it is clear that a holistic approach is required that also addresses psychological and cognitive components of recovery. Other functional instruments with similar domains to the BI or FIM have been used with ICU patients in some studies, but not commonly, and were therefore not included here. Similarly, only common generic HRQOL instruments were reviewed; disease-specific instruments were excluded because of their lack of utility to general ICU patients.

Implications for practice

The assessment of physical function in ICU survivors is multidimensional and involves establishing pre-morbid function, screening for the presence of ICU-AW and monitoring recovery of strength and function in the context of HRQOL. Critical care nurses and ICU liaison nurses should routinely assess strength, functional ability and mobility for their patients to identity those at risk of delayed recovery. In patients who have a prolonged ICU stay complicated by sepsis, ICU-AW should be suspected and an MRC score of muscle strength recorded. For patients with an MRC score of <48, a rehabilitation programme should commence while the patient is in ICU, with recovery monitored using outcomes such as the PFIT and field walking tests. ICU follow-up services should also consider routine assessment of HRQOL for identified patients at risk of delayed and sub-optimal recovery.

Improved education of the wider health care community (e.g. General Practitioners; Community Nurses) about the ongoing legacy of a critical illness, that includes monitoring and responses to weakness and loss of functional capacity, should be implemented.

Recommendations for further research

This review has provided information on instruments available for measuring physical function and activity in survivors of a critical illness. To appropriately assess weakness and poor physical function in survivors of a critical illness and to measure responses to interventions aimed at improving physical function, further validation of some of these instruments and development of new instruments is required. As noted earlier, consensus around the methodology for muscle testing needs to be developed.

Concurrently, assessment and treatment strategies that are safe, feasible and cost effective need to be identified that reduce the risks of developing ICU-AW including changes of culture to less sedation and immobility to more patient activity and targeted rehabilitation programs. Importantly, a 'package' of interventions needs to be developed that target both cognitive and functional outcomes and these need to be tested using rigorous collaborative research in ICU populations, to inform and enable national and international comparisons.

Conclusions

This narrative review described assessment of physical function and recovery during the continuum of critical illness — from in-ICU to the post-ICU hospital and hospital discharge periods. Physical debilitation from a patient's critical illness and treatment may result in a decline in functional capacity, which affects the recovery trajectory for survivors of a critical illness. Assessment of physical function involves clinical assessment of muscle strength, physical activity, mobility and functional ability. The common techniques and instruments were discussed, with limitations or challenges in practice noted. Standardisation in assessment practices and resulting rehabilitation and recovery plans requires consistent engagement from multidisciplinary teams in critical care, but also from physical and medical rehabilitation specialities.

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