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Rationalising Standard Laboratory Measurements

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Laboratory measurements are widely used in the Intensive Care Unit (ICU). This review describes an approach to developing and implementing the use of rationalised laboratory measurements.

Drawing blood and requesting laboratory measurements is probably one of the most frequently performed interventions in critically ill patients. There is probably not a single diagnosis that can be established in the Intensive Care Unit (ICU) or treatment adjustment made that does not benefit from some type of laboratory measurement.

The range of available laboratory parameters is huge and ever increasing (Laposata 2014), and turnaround times for results are shorter than ever, because of improved information technology infrastructure, and, more recently, the increased availability of point-of-care testing. As a result laboratory measurements may appear to be an unlimited resource to the intensivist. However, mindfulness is needed about the limited benefit to patient care and, more importantly, their potential negative impact. Blood drawing aggravates critical care anaemia, which in turn may require blood transfusions with its inherent costs and risks (Vincent et al. 2002). Pathological laboratory results, although not necessarily relevant to a patient's current illness, may prompt further diagnostic or even therapeutic interventions that would otherwise not have been selected (Thomas 2014). Finally, laboratory costs contribute to a substantial proportion of overall intensive care costs (Marini and Wheeler 2006).

Reasons for Laboratory Tests

Laboratory tests may be ordered for a variety of purposes:

• **Diagnostic workup of a critical illness:** laboratory markers play a pivotal role in the diagnostic workup in common problems in the ICU (Vincent 2011);

• **Severity scoring:** commonly used intensive care scoring systems, such as Acute Physiology and Chronic Health Evaluation (APACHE) III-IV, Simplified Acute Physiology Score (SAPS) II and III, the Intensive Care National Audit & Research Centre (ICNARC) score or European System for Cardiac Operative Risk Evaluation (EuroSCORE), require the input of laboratory data to calculate disease severity and probability of mortality (Palazzo 2014);

• **Treatment monitoring:** the treatment of most types of critical illnesses can be guided by laboratory measurements. Examples are: serial determination of inflammation markers in the course of antimicrobials to treat sepsis, or the evolution of renal markers in kidney failure;

• **Daily screening** during the course of a critical illness with the intention of monitoring recovery or for the early detection of complications; most intensivists will request regular, if not daily, routine laboratory tests for this purpose.

Current Practice

The current practice of requesting laboratory measurements is poorly described. Little is known about the rationale for the current use of laboratory measurements in the ICU. Even comprehensive critical care medicine manuals do not dedicate chapters to laboratory testing (Irwin and Rippe 2012).No recommendations or practice guidelines relating to the selection and timing of laboratory measurements have been issued by professional bodies or learned societies (Core Standards Working Party of the Joint Professional Standards Committee 2013). It appears that the choice of laboratory tests is both highly variable, and is influenced by local practice, physician-related factors, such as seniority and level of expertise, location, teaching status, characteristics of the ICU, and patient factors that are not necessarily related to the diagnosis and severity of the critical illness, such as sex, time of admission and age. An increase over time in the number of laboratory tests performed per patient day has

been observed (Spence et al. 2014; Smellie 2012).

Economic Impact of Laboratory Measurements

The economic burden of obtaining laboratory measurements is substantial. It is estimated that laboratory costs may be as high as US $1,000 per patient day. They may account for up to 15% of ICU charges, particularly during the early stages of the treatment (Marini and Wheeler 2006; Garland et al. 2006).

Despite the absence of consensus regarding the most appropriate selection of laboratory tests in any given clinical scenario, there is a commonly held notion that routine laboratory measurements are an overused resource, which should, and can be, curtailed without any negative impact on the overall quality of patient care (Peixoto et al. 2013).

Roadmap Towards Rationalisation of Laboratory Measurements in the ICU

The aim of rationalising laboratory measurements is to promote reasonable and well-balanced use of this valuable yet pricey diagnostic tool. Several steps are necessary to develop and implement a rationalised approach, and secure long-term adherence by clinicians. For a number of reasons the guiding principle throughout the entire process should be “less is more”:

• The number of irrelevant or chance results that are of no significance to a patient’s care should be reduced to a minimum, thus reducing the incidence of unnecessary, costly and/or potentially harmful follow-up interventions;

• Fewer laboratory measurements cause less iatrogenic anaemia and reduce transfusion requirements;

• Direct laboratory tests costs and indirect costs such as labour costs can be better contained.

How to Design and Develop Rationalised Laboratory Panels

A multi-faceted approach is required. Consensus should first be reached among responsible clinicians as to the type of clinical scenarios laboratory panels should be made available for, and which laboratory measurements should be included in each test panel.

The Delphi method is a suitable tool to capture clinician opinions and preferences regarding useful laboratory tests, and to develop rationalised sets of laboratory panels (Lang and Secic 2006). During this process the costs of each laboratory parameter should be considered. Depending on local reimbursement schemes and internal cost allocation, the costs of routine parameters may vary substantially. Even supposedly ‘cheap’ laboratory parameters can contribute to substantial annual costs if requested frequently. Performing an ABC analysis is helpful for identifying the most costly items of an existing laboratory inventory (Vollmann 2005).

Examples of rationalised laboratory panels as in current use in multidisciplinary ICU are shown in Table 1.

	Daily panel for Intensive Care	Daily panel for High-Dependency & Step-down	Liver panel	Infection panel	Post-cardiac surgery panel
Red cell count & haemoglobin	x	x		x	x
White cell count	x	x			x
Differential white cell count				x	
Platelet count	x	x		x	x
International normalised ratio	x		x		
AST			x		
ALT	x		x		
Albumin			x		
Alkaline Phosphatase			x		
Sodium		x			
Potassium		x			
Bilirubin (total)			x		
γ-GT			x		
Creatinine-Kinase					x
Creatinine-Kinase MB isoenzyme					x
Creatinine	x				
Troponin					x
Urea	x				
Point-of Care: Arterial Blood Gas Analysis, Oximetry, Lactate, Glucose Sodium, Potassium, Calcium Chloride	x				x
Glucose		x	x		
C-reactive Protein	x			x	
Costs CHF (USD)	74 (81)	29 (32)	32 (35)	42 (46)	77(85)

Table 1: Laboratory Panels for Typical Scenarios in a Multidisciplinary Intensive Care Unit

Guidelines and Laboratory Request Forms

Written laboratory testing guidelines should be developed and proactively implemented, using appropriate educational interventions. They should remain readily available at the bedside (Kumwilaisak et al. 2008). Laboratory guidelines have been shown to significantly reduce the number of tests performed per patient (Mehari and Havill 2001). Laboratory request forms should be redesigned to reflect the recommended laboratory panels (Smellie 2012). It may be beneficial to implement a policy of senior clinician approval for advanced testing (Thomas 2014).

Staff Education

Staff education aims to create awareness and understanding about the need to rationalise laboratory measurements and their practical use. The significance of this cannot be overstated. Educational activities should be initiated prior to implementing rationalised laboratory panels, and continue during and after the implementation phase.

Staff should be educated to develop a balanced view about the merits and disadvantages of laboratory testing:

• More diagnostic testing does not equate to high quality care (Marini and Wheeler 2006). It is better to thoroughly examine a patient rather than order routine laboratory tests;

• Prior to ordering a laboratory test, the consequences of a positive or negative result need to be considered: if any test result, either positive or negative will have no consequence, then the test should not be done (Marik 2010);

• Knowledge of basic statistical principles is required to correctly interpret positive and negative test results: if the pre-test probability of any given disease is low, a positive test result is unlikely to indicate the presence of disease. Likewise a negative test result does not prove the absence of disease (Haynes 1981).

Developing Positive Staff Attitude and Promoting Behavioural Change

Multifaceted educational interventions are reportedly more effective than single interventions for changing staff behaviour (Greco and Eisenberg 1993). As soon as sets of rationalised laboratory panels and laboratory-testing guidelines have been developed, they should be disseminated through the appropriate communication channels, such as staff meetings, peer group educational discussion meetings, email and the hospital intranet.

Securing Long-Term Adherence

One-off interventions do not produce sustained change (Smellie 2012). Ongoing usage of rationalised laboratory measurements can be achieved using a combination of: continuing education in the form of ‘top-up’ educational interventions (Larsson et al. 2009), teaching during the orientation of new nursing and medical staff, and simply by facilitating guideline accessibility at the bedside (Mehari and Havill 2001). Outreach visits by experts, combining personalised feedback, education and small group discussion is an additional, albeit costly, method for promoting the use of rationalised laboratory measurements (Verstappen et al. 2004).

Information Technology and Decision Support Systems

Rationalisation of laboratory measurements can be developed further by using neural modelling and fuzzy logic. These technologies can be employed to select the most useful laboratory tests for a given clinical scenario (Cismondi et al. 2013). Automated decision support systems, involving computer prompting connected to the electronic laboratory order form, have also been shown to improve the appropriateness of laboratory requests (Kawamoto et al. 2005).

Conclusion

• The aim of rationalising laboratory measurements is to improve the efficiency of patient care and reduce costs;

• Laboratory panels should be developed at the local level by consulting with expert clinicians;

• Staff education plays a pivotal role when implementing the concepts of rationalised laboratory measurements, as well as with supporting long-term adherence;

• Information technology can contribute significantly to the improved use of rationalised laboratory measurements.

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