ORIGINAL ARTICLE
Serum uric acid and albumin levels and estimated glomerular filtration rate: oxidative stress considerations

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Although there is information with regard to the presence of oxidative stress in various diseases, the mechanisms of this oxidative stress is yet to be fully elucidated or explained. Oxidative damage is reported for most diseases but clear correlation between most diseases and oxidative stress is lacking. This is perhaps due to little knowledge of the molecular mechanisms leading to oxidative stress and of the methods that measure oxidative stress (Giustarini et al 2009).

Oxidative stress can contribute towards renal injury (Sarafidis et al 2006; Sarafidis and Grekas 2007; Karamouzis et al 2008) and reactive oxygen species are implicated in various diseases including renal disease (Cachofeiro et al 2008). The levels of certain markers of oxidative stress increase with increasing degrees of renal dysfunction and it has been shown that reactive oxygen species increase in a graded manner as renal function deteriorates (Cachofeiro et al 2008; Ferretti et al 2008; Karamouzis et al 2008). Inverse correlations between different markers of oxidative stress and glomerular filtration rate (GFR) have also been reported (Terawaki et al 2004; Cachofeiro et al 2008). For instance, Terawaki et al (2004) using the redox state of human serum albumin as a marker of oxidative stress reported that oxidised albumin was increased before dialysis and had an inverse correlation with renal function.

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uric acid could protect against ischaemic injury in mice. In addition to being a radical scavenger, uric acid can chelate metal ions such as iron and copper, converting them to poorly reactive forms that are unable to catalyse free radical reactions (Davies et al 1986; Glantzioussi et al 2005).

Although hyperuricaemia has been proposed to be a major antioxidant, it has also been shown to be associated with the development of a number of diseases including kidney failure (Alderman et al 1999; Johnson et al 2003; Sautin and Johnson 2008). Therefore, there is also the potential for hyperuricaemia to be pro-oxidant. The pathogenesis of many diseases is not clear, but oxidative stress appears to be a common feature (Berg et al 2004; Furukawa et al 2004; Stocker and Keaney 2004; Wellen and Hotamisligil 2005; Houstis et al 2006; Sautin and Johnson 2008) and with the ability of uric acid to be pro-oxidant under certain conditions, this creates the urate oxidant-antioxidant paradox (Sautin and Johnson 2008).

It is important to note that most antioxidants become pro-oxidants by default as a metabolic by-product of an antioxidation reaction. It is the process of regenerating an antioxidant from its pro-oxidant form by other antioxidants (e.g. vitamin C regenerates GSH from GSSG) that culminates in co-antioxidant interactions. Therefore, the ability of uric acid to become pro-oxidant may not counter its antioxidant property, but connotes the possible existence of regenerating co-antioxidant. The issue is that the concept of uric acid as a powerful antioxidant challenges the traditional notion regarding the metabolite being a toxic waste product of metabolism. It is therefore important to understand the urate oxidant-antioxidant paradox.

On the subject of cardiovascular events, Johnson et al (2003) noted that the beneficial actions of uric acid may counter its potential detrimental effects hence it may not be an independent risk factor for the disease. Such observations warrant the studying of the protective and/or toxic effects of uric acid in various diseases. Increases in uric acid in renal disease due to reduction in GFR and renal urate excretion (Johnson et al 2003) could be beneficial in protection from oxidative stress. Whether hyperuricaemia is a biomarker for antioxidant capacity or oxidative stress status is an impasse to resolve for diagnostic utility. Hence it is important to investigate its association with stages of estimated glomerular filtration rate (eGFR).

Hypothesis

In the context of renal dysfunction and assuming absence of any confounding factor, low eGFR and hypoalbuminaemia as well as hyperuricaemia are implicated. We hypothesize that if hyperuricaemia in renal disease (due to reduction in GFR) is beneficial in protection from oxidative stress, then the increase in uric acid level would not have a significantly negative correlation with eGFR and serum albumin level, because of the metabolic conversion of uric acid in the process of antioxidation reaction. If this is not the case, hyperuricaemia could be just accumulation of waste product of metabolism and more of a toxic pro-oxidant than antioxidant.

Objective of study

In consideration of the report of Terawaki et al (2004) on albumin’s inverse correlation with renal function in addition to our hypothesis, this retrospective pilot study investigated serum uric acid and albumin levels and eGFR with a view to establishing correlation among these routinely assessed clinical parameters. The presence of any existing disease and medication were not taken into account at this preliminary stage.

Materials and methods

Ethical considerations

This work is part of a clinical laboratory-based Biomedical Science Research supported materially by Albury South West Pathology, a unit of the Pathology West of NSW Health, Australia. The Ethics Committee of the Area Health Service approved the use of the de-identified data. All tests were performed at the Albury laboratory of South West Pathology.

Data

This preliminary retrospective study looked at data from South West Pathology, NSW for 2008 on eGFR, serum uric acid and albumin levels to investigate correlations among these parameters. This data involved 274 results of males (120) and females (154) and did not take into account any other disease or medication as this was sometimes not recorded. The ages ranged from 19 to 90 years and an average age of 60.1 years.

Serum albumin was measured as part of routine ‘liver function testing’. eGFR was estimated and generated automatically for qualifying patients who had renal function panels, comprising electrolytes, urea and creatinine performed. All tests were measured using the Dimension® RXL (Siemens) automated analyser. Estimated GFR was calculated according to the modified Diet in Renal Disease (MDRD) formula as follows:

Males = 175 x (CREA / 88.4)\(^{-1.154}\) x age\(^{-0.203}\) x 1
Females = 175 x (CREA / 88.4)\(^{-1.154}\) x age\(^{-0.203}\) x 0.742

eGFR was reported (i) for patients from ages ≥ 18 years; (ii) not reported if creatinine levels had risen > 70 µmol/L in previous seven days; and (iii) as > 60 mL/min if estimate was more than 60 mL/min.

Statistical analysis

The aim of the analysis was to define the strength of the relationship between eGFR, albumin and uric acid. This was achieved using a two-step procedure in which...
the partial correlations between these response variables were calculated. As the data resulted from an observational study where the results were likely to be affected by age and gender among other variables, an analysis of covariance was used to account for these effects. The residuals that were obtained from these models were then subjected to a partial correlation analysis.

A different analysis of covariance model was required for each variable to ensure that the residuals conformed to the usual assumptions of normality, independence and constant variance. The model for eGFR included the main effect of gender, terms for a second order polynomial regression on age and their interactions. A power transformation was used on the eGFR result to ensure the model assumptions were met. Albumin and uric acid were also transformed using power transformations however a simpler model with the main effect of gender, the simple linear regression on age and the interaction of these two terms was used.

**Results**

Tables 1-3 show a decrease in serum albumin levels as eGFR goes down and at the same time an inverse relationship is observed between eGFR and serum uric acid levels and eGFR and age. This relationship is seen in both sexes.

<table>
<thead>
<tr>
<th>Table 1. Average eGFR, age, serum albumin and uric acid levels* at various eGFR ranges in females.</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
</tr>
<tr>
<td>&lt;30</td>
</tr>
<tr>
<td>31-40</td>
</tr>
<tr>
<td>41-50</td>
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<td>51-60</td>
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<tr>
<td>61-70</td>
</tr>
<tr>
<td>71-80</td>
</tr>
<tr>
<td>81-90</td>
</tr>
</tbody>
</table>

*Raw data, which were transformed for partial correlation analysis

<table>
<thead>
<tr>
<th>Table 2. Average eGFR, age, serum albumin and uric acid levels* at various eGFR ranges in males.</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
</tr>
<tr>
<td>&lt;30</td>
</tr>
<tr>
<td>31-40</td>
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<tr>
<td>41-50</td>
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<td>51-60</td>
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<tr>
<td>61-70</td>
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<tr>
<td>71-80</td>
</tr>
<tr>
<td>81-90</td>
</tr>
</tbody>
</table>

*Raw data, which were transformed for partial correlation analysis

The simple correlation (Pearson’s correlation coefficient) was initially calculated using the raw data. There was a weak positive relationship between eGFR and serum albumin levels (r = 0.11), and this correlation was not statistically different from zero (p = 0.698). The correlation between serum uric acid and serum albumin levels was essentially equal to zero (p = 0.963). eGFR and serum uric acid levels had a stronger negative correlation (r = -0.363). This correlation was the only simple correlation that was significantly different to zero (p < 0.001).

The partial correlation analysis confirmed the results from the simple correlation tests (Table 4). After accounting for sex and age, eGFR and serum albumin levels had a partial correlation of (r = 0.0690). This partial correlation was not statistically different from zero (p = 0.257). The partial correlation between eGFR and serum uric acid, after accounting for sex and age, was statistically different to zero (r = -0.32; p < 0.001). After accounting for sex and age the correlation between serum albumin and uric acid was not significantly different from zero (r = -0.07; p = 0.246).

**Discussion**

The inverse relationship between GFR and age observed (Tables 1-3) is not surprising as studies have shown that GFR declines with advancing age. USA and Finnish studies have shown that GFR progressively increases up to 18 years and declines thereafter (Wahl et al. 2003). Berg (2006) found significant decline in absolute and relative GFR with age in males as early as 20 years, but not in females. Wesson (1969) cited in Berg (2006), reported delayed and slower fall in GFR with age in women. Some authors have however stated that GFR is about the same...
in males and females when GFR is related to body surface area (Rule et al. 2004; Grewal and Blake 2005) and there appeared to be no differences in GFR between the sexes in this study.

Serum uric acid levels progressively increased as eGFR decreased (Tables 1-3) in both sexes in this study. Furthermore, eGFR and serum uric acid levels had negative correlation after accounting for sex and age. This observation is possibly a demonstration of the lack of evidence that the un-excreted uric acid is being used as antioxidant perhaps protecting against a decline in GFR. Therefore, we uphold the traditional opinion that hyperuricaemia is the accumulation of waste product of metabolism and infer that it may be more of a toxic waste (including pro-oxidant potentials) than antioxidant.

Miyatake et al. (2011) found in Japanese men without medications and after one year of life-style changes (including balanced nutrition and exercise), a negative correlation between changes in eGFR and changes in serum uric acid levels, and concluded that reducing uric acid levels could be useful for improving eGFR. Using longitudinal analysis, Yen et al. (2009) showed that serum uric acid levels were associated with eGFR and decline in renal function in elderly Taiwanese subjects. The authors reported that asymptomatic hyperuricaemia was observed in chronic kidney disease, possibly a reflection of decreased renal uric acid excretion and this could also be responsible for pathogenic progression of chronic kidney disease through various mechanisms.

The mechanisms underlying the association between high values of uric acid and diminishing renal function would benefit from further elucidation. Serum uric acid can function as a pro-inflammatory molecule with capacity to act as a pro-oxidant and as an antioxidant as well (Johnson et al. 2003; Rosolowsky 2008). Increased serum uric acid level may augment the risk for development of renal disease. For example in a community-based study of Japanese adults, hyperuricaemia emerged as the only significant risk factor of renal failure besides age, and it was reported to be strongly more predictive than proteinuria (Iseki et al. 2001; Rosolowsky et al. 2008). Elevated uric acid levels can cause endothelial dysfunction through stimulation of vascular smooth muscle proliferation resulting in thickening of afferent arterioles of glomerulus, and hyperuricaemia inhibits the release of nitric oxide within the vasculature of the kidneys hence reducing renal blood flow and GFR (Johnson et al. 2003; Weaver et al. 2005; Alasia et al. 2010).

In this study we observed a decrease in serum albumin levels that loosely corresponded to a decline in eGFR (Tables 1-3). Decreased levels of serum albumin have been shown to predict mortality in patients with end stage kidney disease and in patients with acute renal failure (Chertow et al. 1998; Obialo et al. 1999; Owen 1993; Chawla et al. 2005). In critically ill patients, decreased levels of serum albumin have often been ascribed to poor nutritional status but serum albumin level can also fall significantly in response to inflammation and capillary leakage (Moshage et al. 1987; Chawla et al. 2005). Hypobuminemia is highly prevalent in kidney failure and is associated with an increased mortality risk (Foley et al. 1996; Menon et al. 2005); enhanced protein catabolism by pro-inflammatory cytokines in inflammation and nutritional status are possibly involved (Menon et al. 2005). No correlation was observed between serum uric acid levels and serum albumin levels in this pilot study (Table 4). Given that renal dysfunction indicated by low eGFR may cause hyperuricaemia concomitant with hypoalbuminema, it is logical to expect that serum uric acid level would be inversely correlated with serum albumin concentration as it is associated with eGFR. Therefore, the observation of no correlation may be an apparent demonstration of complex pathophysiology and perhaps the influence of medication that the patients could have been taking. The study did not examine a particular disease, medication or population. However, among Taiwanese adults with type 2 diabetes mellitus, Tseng (2005) reported that hyperuricaemia correlated with increased albumin excretion rate. A direct correlation between GFR and serum albumin levels in children with nephrotic syndrome has also been observed (Lowenberg and Berg 1999).

This study is cognisant of the fact that medication and types and duration of diseases were not considered. The major aim was to see if a relationship existed between eGFR and serum uric acid and albumin levels. Further research is needed to particularise diseases in relation to serum uric acid and albumin levels. Urinary albumin needs to be measured with a view to separate kidney diseases presenting with albumin loss and those that do not. Use of Modification of diet in renal disease (MDRD) formula (Levey et al. 1999) may underestimate rate decline in GFR (Lippi et al. 2009) and this is pertinent in correlation studies and when relating GFR to age.

**Conclusion**

An inverse relation between eGFR and age was observed. Serum uric acid levels and eGFR showed an inverse relationship. Decreased serum albumin levels were not significantly associated with declining eGFR or serum uric acid levels. The observations may be an indication of the non-existence of significant metabolic process such as antioxidant to counteract the accumulation of toxic uric acid associated with renal disease. More studies need to be carried out on eGFR, uric acid and albumin levels focusing on the contributions of antioxidant and pro-oxidant properties of uric acid as well as albumin in oxidative stress, which is known to contribute to kidney disease.

**Conflict of interest**

None declared.
References


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There is increasing awareness in the community of the need for organisations and individuals to be responsible for their environmental footprint. Waste in the form of power, recyclables, chemicals or water represent cost and potential pollution. Drought, increased water costs, concerns about the viability of coal burning power plants, and the ever increasing cost of power are daily reminders of the need to conserve and recycle.

Organisations such as IBM, Lockheed Martin, United Technologies, 3M, Ford and Digital Equipment Corp have all declared their commitment to environmental responsibility by implementing the Environmental Management Systems ISO 14001:2004 (ISO EMS). Clinical Laboratories can be high polluters because of the volume and range of chemicals used, the high water requirements and the high power consumption. Laboratory staff are often aware of the waste generated in their daily work activities, yet feel powerless to reduce this waste. Sullivan Nicolaides Pathology (SNP) is a large private pathology organisation comprising a central laboratory located in Brisbane and some 20 satellite laboratories spread throughout Queensland and northern New South Wales. The central laboratory is based in Brisbane and the regional laboratories involved with this implementation were based at Coffs Harbour and Grafton. The organisation is accredited to ISO 15189 (International Organisation for Quality 2007) and employs some 2000 full time equivalent (FTE) staff. At SNP it was decided to implement ISO 14001 to address these issues.

Many publications expound the desirability of pursuing an environmentally conscious business approach. However, we are not aware of any publications from clinical laboratories describing either implementation or the quantitative benefits arising from adoption of an EMS.

In 2006 SNP began working towards ISO EMS Environmental Management Systems implementation and certification at the Coffs Harbour and Grafton Laboratories. SNP initially chose to seek certification to ISO 14001 level rather than just implement an environmental management policy. This path was selected so that the organisation would be recognised as a leader in environmental protection as well as to reduce environmental risks, improve community relations and lower operating costs. It is likely that in the near future governments will implement more rigorous environmental legislation and having an externally audited EMS may provide greater flexibility.

Sullivan Nicolaides Pathology, a large private pathology laboratory group in eastern Australia, made the decision in 2006 to implement an Environmental Management System (EMS) in order to complement and expand their existing Quality Management System (QMS). All aspects of laboratory operations were reviewed, including analytical, courier, clerical, and collection, and the environmental aspects and impacts assessed. Staff at all levels were engaged and given environmental training, and a register of legal and other requirements established. Certification to ISO14001:2004 (International Organisation for Quality 2004) was achieved in several sites in 2009. In addition to minimising the environmental impact of the pathology laboratories, real financial savings and a positive corporate image were achieved through reduction of resources and waste, and improved operational efficiencies.

Keywords: Resource management, pathology laboratory, ISO14001 certification

Introduction

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Abstract

Sullivan Nicolaides Pathology, a large private pathology laboratory group in eastern Australia, made the decision in 2006 to implement an Environmental Management System (EMS) in order to complement and expand their existing Quality Management System (QMS). All aspects of laboratory operations were reviewed, including analytical, courier, clerical, and collection, and the environmental aspects and impacts assessed. Staff at all levels were engaged and given environmental training, and a register of legal and other requirements established. Certification to ISO14001:2004 (International Organisation for Quality 2004) was achieved in several sites in 2009. In addition to minimising the environmental impact of the pathology laboratories, real financial savings and a positive corporate image were achieved through reduction of resources and waste, and improved operational efficiencies.

Keywords: Resource management, pathology laboratory, ISO14001 certification

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Implementing ISO 14001 is a major organisational exercise which can take some years, although having ISO 9000 in place can significantly reduce the time required. SNP had had ISO 9001 (International Organisation for Quality 2008) in place for nearly 10 years and the language of quality management systems was well understood. The Plan-Do-Check-Act (PDCA) cycle, comprising audits, management review, the investigation of non-conformances, and corrective actions were part of the organisational landscape. SNP has a proactive Workplace Health and Safety system, and has implemented Lean management, both of which support environmental management with their focus on risk management strategies, disaster mitigation, and reduction of resources, energy and waste.

The cost of implementation varies depending on the pace of the implementation and the use or not of external consultants. The greatest challenge to any organisational change is the recognition by staff of the value of the change and then the pace at which the staff fully engage in the process of change. ISO 14001 has at times been portrayed as an expensive, resource intensive endeavour so our aim was to demonstrate real financial and work flow savings that were directly attributable to the implementation. SNP chose not to use external consultants and to implement at a gradual pace, implementing waste reduction, energy and water saving strategies first and then formally seeking certification of sites to ISO 14001. The order and speed of implementation was driven by the staff and managers at individual sites as they perceived the benefits of the process.

Methods

SNP had ISO 9001 in place for over 10 years when the decision was made to implement ISO 14001. The first sites chosen were the Coffs Harbour and Grafton Laboratories for several reasons.

a) The Coffs Harbour laboratory was being re-located to a purpose built site, allowing us to have input into the design and features of the building.

b) The Coffs Harbour and Grafton sites have the same laboratory manager and share a quality management system and manual.

c) The manager has a strong environmental focus and educational back ground.

d) The Coffs Harbour and Grafton laboratories were already in the process of reviewing all discharge into the sewer system in accordance with the recently introduced New South Wales Liquid Trade Waste Guidelines.

e) The Grafton site is an existing site. It would allow us to compare and contrast the application of the standard to a new and existing site.

Initial environmental reviews were carried out, including the determination of significant environmental aspects and impacts. It was decided that the scope would include all departments, including laboratory, collection, couriers, and administration. The environmental impact of each aspect under normal, abnormal and emergency conditions was considered. “Normal” conditions are routine operating conditions; “abnormal” are unusual but controlled and/or scheduled conditions, such as start-up, shut-down, or maintenance. “Emergency” conditions are uncontrolled and unscheduled, such as fire, chemical spill, or flood. In each case, any actions or changes to procedures or equipment that could minimise the potential impact were identified.

Legal and other requirements, such as industry-specific, local, state and federal guidelines, regulations and legislation were identified. An audit to ensure compliance was conducted, and a legal register established.

For each environmental aspect of the business objectives, targets and programmes were set.

An example of the process is given in Table 1 which details for a particular site the action plan to reduce the use of paper.

Initially, each aspect was monitored for 12 months to gain baseline data. This was sourced from local Council records, invoices, inventory ordering information and monitoring programs. Based on this data, targets were set and programs implemented to meet these targets. Progress was monitored via monthly reviews and audits. Where necessary, targets were revised, or processes altered.

Documentation specific to the EMS was established. This included the Local Environmental Management System, emergency planning / spill kit documents, contractor site manual/ register, audit schedule, and training packages.

Prior to implementation, there was a full corporate audit against ISO 14001, and a system review.

As SNP had had a QMS for over a decade, Management Review Meetings were regularly held. At the Corporate level, specific environmental Management Review Meetings were held. At the local level, environmental aspects were included under all the established items, such as audits, corrective actions, customer complaints, training etc., and Environment was introduced as an additional item into the agenda.

Staff training (management and general staff) was vital to achieving success. Many staff are practising environmental responsibility at home, but felt overwhelmed by the volume of waste generated in the workplace to which they contributed to by their daily activities. Therefore, many were very receptive and keen to take part. In-service
Training sessions were held to introduce the aim and the process. Training packages were developed for staff and managers. Whenever new processes were introduced, the aim was to make them as simple and logical as possible, so that compliance would be the easiest process. Green noticeboards were introduced into all laboratories to keep staff informed on progress of programs, new initiatives, and local environmental initiatives, such as Landcare support (Landcare 2012).

Training of contractors was undertaken to ensure that they are aware of the importance SNP places on the environment, and that they should also mitigate their environmental impact. Wherever possible, contractors using environmentally friendly products and processes are preferentially selected. Contractors are encouraged to look at alternatives to non-sustainable materials and processes.

Pathology organisations have many stakeholders including staff, contractors, patients, referrers and the community. There are great expectations from all these groups about environmental awareness and action and often it is only when there is an incident that the community becomes aware of the hazardous nature of an industry. Presentations to stakeholders aim to educate the public, patients, Councils and focus groups about our environmental responsibility, and the benefits to SNP and to our communities. This includes public display of our Environmental Policy in all

### Table 1. Examples of the targets and action plans used in the Implementation Process

<table>
<thead>
<tr>
<th>Programmes / procedures</th>
<th>Responsibility*</th>
<th>Timeframe</th>
<th>Associated records</th>
<th>Storage location / responsibility</th>
<th>Retention time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor plain paper usage</td>
<td>Assistant Laboratory Manager</td>
<td>Three monthly updates</td>
<td>Usage data from purchasing (cost centres 8082, 8005)</td>
<td>Refer Supply department</td>
<td>Refer Supply department</td>
</tr>
<tr>
<td>Plain paper usage graphs</td>
<td>Assistant Laboratory Manager</td>
<td>Three monthly updates</td>
<td>Usage graphs</td>
<td>Staff noticeboard / intranet</td>
<td>12 months</td>
</tr>
<tr>
<td>Monitor printer / copier consumables usage</td>
<td>Assistant Laboratory Manager</td>
<td>Three monthly updates</td>
<td>Usage data from Purchasing</td>
<td>Refer Supply department</td>
<td>Refer Supply department</td>
</tr>
<tr>
<td>Printer / copier consumables usage</td>
<td>Assistant Laboratory Manager</td>
<td>Three monthly updates</td>
<td>Usage graphs</td>
<td>Staff noticeboard / intranet</td>
<td>12 months</td>
</tr>
<tr>
<td>Report for Corporate MRM</td>
<td>Toowong Sherwood Road Environmental Committee</td>
<td>Six monthly</td>
<td>Meeting minutes</td>
<td>Meridio</td>
<td>Three years</td>
</tr>
<tr>
<td>Train staff in EMS01</td>
<td>Practice Environmental Systems Coordinator</td>
<td>As required</td>
<td>Training attendance records Assessment forms Certificates</td>
<td>Meridio</td>
<td>Life of employment plus three years</td>
</tr>
<tr>
<td>Monitor energy usage for 12 months</td>
<td>Assistant Laboratory Manager</td>
<td>To be completed for the whole of 2010</td>
<td>Outgoings for tenancy</td>
<td>SNP Accounts Payable</td>
<td>Seven years</td>
</tr>
<tr>
<td>Energy usage graphs</td>
<td>Assistant Laboratory Manager</td>
<td>Three monthly updates</td>
<td>Usage graphs (Note: meeting and training events)</td>
<td>Staff noticeboard / intranet</td>
<td>12 months</td>
</tr>
<tr>
<td>Maintenance of air-conditioning units</td>
<td>Building management</td>
<td></td>
<td>Refer to building management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance of split-system air conditioning units</td>
<td>Essential Services</td>
<td>Units currently under warranty</td>
<td>Paper records held by Essential Services</td>
<td>Essential Services / Facilities Coordinator</td>
<td>12 months</td>
</tr>
<tr>
<td>Train staff in EMS01</td>
<td>Practice Environmental Systems Coordinator</td>
<td>As required</td>
<td>Training attendance records Assessment forms Certificates</td>
<td>Meridio</td>
<td>Life of employment + three years</td>
</tr>
</tbody>
</table>
Collection Centres, laboratories and on our website, and presentations to stakeholder groups.

Results

The Grafton and Coffs Harbour laboratories were certified to ISO 14001 at an audit held in May 2009, followed by the Lismore laboratory, and the administration hub at the central laboratory.

The Coffs Harbour laboratory was designed to reduce energy consumption by maximising the use of natural light, installing "smart" lighting responsive to ambient light levels, movement sensors in toilets and low use areas, and window tinting. Rainwater is used to flush toilets and water the gardens, which are stocked with drought-resistant plants. A 1,000 L holding tank has been installed as a disaster-mitigation in the event of a chemical spill.

The laboratory treats all haematology/histopathology stains by passage through a carbon column prior to discharge. The waste wash liquid from analysers is held in waste containers rather than directly discharged to the sewer system, and the pH is checked and adjusted. Xylene is recycled on site, and formalin treated by an aldehyde-flocculating agent to remove formaldehyde prior to disposal.

Initiatives and outcomes

From the implementation process, a number of practice-wide environmental initiatives have been introduced and form part of SNP’s EMS.

Recycling

One of the tenets of an effective environmental policy is the focus on waste reduction, a major branch of which is to increase the amount of recycling. There are a variety of recycling programs in place at SNP. These include paper / cardboard, co-mix (plastic, glass and metal), printer cartridge recycling, mobile phone recycling, polystyrene recycling, fluorescent tubes recycling, chemical (eg. xylene and alcohol) recycling, and water (main laboratory – capture of waste from the de-ionised water production system overflow)

We shall describe the quantitative recycling outcomes.

1. General recycling

In the period from January 2008 to December 2009 for the Taringa site, diversion of waste from landfill increased from 6% to 17% (peak in September 2009).

Co-mingle recycling increased from 8 m$^3$ to 25 m$^3$ / month.
In 2008, a total of 297 m$^3$ of waste was recycled, an average of 24.75 m$^3$ / month. By 2009, this had increased to a total of 492 m$^3$ of waste recycled, or an average of 41 m$^3$ / month.

Waste is defined as clean white office paper, co-mingle and shredding. These statistics exclude cardboard recycling. As can be seen from Table 2, below, recycling is 40-51% cheaper to dispose of than general waste.

**Table 2. Comparative cost of recycling different waste streams**

<table>
<thead>
<tr>
<th>Waste type</th>
<th>Cost per container</th>
<th>Cost per litre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-mingle &amp; clean white office paper</td>
<td>$3.09 / 240L</td>
<td>1.28 cents/L</td>
</tr>
<tr>
<td>Cardboard</td>
<td>$10.50 / 1100L</td>
<td>0.95 cents/L</td>
</tr>
<tr>
<td>General waste</td>
<td>$14.17 / 600L</td>
<td>2.36 cents/L</td>
</tr>
</tbody>
</table>

It is anticipated that landfill prices will increase with the implementation of federal environmental policies.

2. **Printer cartridge recycling**

Total amount of printer waste diverted from landfill from July 2007 to March 2012 was 8.9 tonnes.

3. **Xylene recycling**

By recycling xylene on site, there is a reduced risk of an environmentally significant spill (i.e. less is stored), a reduction in environmental impact from transport and disposal of the product, as well as the associated financial savings of reduced disposal and purchase costs. For example, the Coffs Harbour laboratory uses approximately 15 L xylene per week. Prior to recycling on site, this was purchased, stored, and used. After use, the waste xylene was stored on site prior to removal by a licensed contractor and transported to Brisbane (400 km) for recycling. With recycling on site, approximately 20 L per year is purchased, and there are no costs associated with storage of waste, or transport and disposal fees. The cost of the recycler will be recouped in approximately five years. In laboratories with higher volume use, this time would be reduced.

4. **Treatment of stains**

The chemicals used to stain blood films were traditionally washed down the sink, and this practice continues in many laboratories today. This is not environmentally responsible, so initially the stains were transported to Brisbane with a licensed contractor for disposal as mixed chemicals. The cost of this disposal was $135 for a 10 L drum, in addition to which is the environmental cost of transport. A solution was found by designing a column made from PVC pipe (1m x 35mm), filled with activated carbon. The stain binds to the activated carbon in passage through the column, leaving a colourless salt solution. When some colour appears in the wash, the carbon residue is changed. In this way, 0.5 kg carbon ($14.00 per kg) can treat 30 L of stain, a cost saving of 5,800%.

5. **Energy consumption**

As part of ISO 14001 implementation, reduction targets for energy usage are set.

These targets may be achieved by installation of energy efficient lighting, use of natural light in building design, window tinting, movement sensors, policies whereby lights and some equipment are turned off after hours, implementation of more energy efficient equipment (e.g. refrigerators, flat screen monitors, etc.), regular maintenance of equipment and consolidation of resources (e.g. refrigerators, freezers and incubators) and removal of obsolete or under-utilised items. Figure 3 below, gives the energy consumption of the new Coffs Harbour site, which was built using “smart” lights, which respond to ambient light, maximum use of natural light, and window tinting to reduce heat. By on-going review of equipment and processes, such as rebalancing the air-conditioning system to adjust for placement of new equipment, auditing power usage by individual pieces of equipment, and turning down PC screens, it has been possible to continue reducing power consumption.

With energy prices continuing to increase across Australia (NSW and QLD prices have increased by 36% and 32%, respectively, over the past three years and prices in NSW are expected to increase a further 64% over the next three years), reduction in energy consumption translates directly into cost savings.

6. **Water consumption**

Water consumption is a major consideration in Australia, which experiences regular drought and flood cycles. The new laboratory site in Coffs Harbour included a 30,000L underground rainwater tank, harvested from the roof of the building. This water is used to flush the dual flush toilets and water the gardens, which are stocked with drought tolerant plants. Despite business growth, water use has not increased (see Fig. 4 below). Similarly, the main laboratory at Taringa has installed rainwater tanks which are used to flush toilets. The analytical water purification system in Taringa, a reverse osmosis system, generates some waste water. This is captured and fed into the rainwater tanks. All staff are reminded to report dripping taps, and to be waterwise.

In addition to these engineering changes, SNP policy has moved to incorporate a higher rate of hand disinfecting by use of alcohol free hand rub to replace some of the hand washing procedures, without compromising hygiene. The results so far in 2012 show a marked reduction in water use compared with the same time last year.

**Practice policies**

Revising established procedures in routine operations at the lowest levels can have a significant effect in reducing environmental impact and cost, without impacting on the quality of the product.
1. **Serum Separator Tube (SST) (Becton Dickinson, Sydney, Australia) blood collection tube usage**

In 2006 there was a change in our test code manual and collection policy, whereby the majority of patient requests required a maximum of one 10 mL SST (serum) tube of blood collected / episode, rather than two or three. As a result, there has been an increase in the number of single SSTs collected per episode from 62% in March 2006 to 85% in July 2009. By making this change, 600,000 fewer SSTs in 2009 were collected, transported, refrigerated and disposed of in the laboratory. This equates to a cost saving in the amount of tubes purchased of $108,000 pa (based on $18 / 100 tubes). The saving in clinical waste costs is 10,200 kg less waste, or $7,548 pa (based on an average weight of one SST = 17g; cost of clinical waste per kg = $0.74.)

2. **Paper usage**

SNP uses around 20 million A4 sheets of paper per year (excludes external publications). Pathology reports comprise about 7.5 million per annum and this has been constant, despite business growth. This is due to the increased referrer uptake of non-paper report options.

Plain A4 has remained static over four years, despite business growth and the opening of numerous new collection centres. Until 2011, the majority of the 300+ SNP Collection Centres were paper-based. However, as connectivity is rolled out across the Practice, it may be anticipated that the paper usage figures will decline further.

The lack of growth in use of plain A4 paper demonstrates that individual actions and introduction of paperless systems (e.g. electronic document management systems and patient request scanning) are making a difference. Comprehensive paper usage audits are currently being conducted. After the initial findings have been collated, a new practice wide reduction target will be set. Future savings will be seen with enhanced usage of electronic storage and electronic information transfer.

Paper is in fact only part of the environmental impact. The associated major impact is transportation, electricity, printers, printer consumables, envelopes, paper storage and disposal. From a cost perspective, paper constitutes only a very small proportion of the cost of the paper cycle.

By maintaining paper usage at steady level / decreasing usage, SNP have been able to minimise the impact of cost rises.

3. **Specimen bag usage**

Specimen bag recycling was re-introduced to SNP in late 2007. These are recycled internally, with new bags given to referrers. Any bags with visible contamination are discarded.

There has been a 55% decrease in the amount of small plastic specimen bags ordered across the practice, since 2006-2007. Numbers have decreased from about 3.58 million to 2.7 million in 2008 to 1.6 million by 2011. This is equal to a saving of around $52,000 per year. The recycling of large zipper bags has saved around $14000 per year.

As per our recycling policy, a new specimen bag is required for each external collection. Approximately one third of all episodes are external collector collections (doctor, nurse or patient). Therefore, the target will be set at 1.5 million bags to be ordered per year.

4. **Recycled vacutainer barrels**

SNP cleans and reuses vacutainer (Becton Dickinson, Sydney, Australia) barrels used in collection of blood. This is a process which has no impact on the quality of the sample or safety to the patient. This has an enormous environmental benefit, compared to single use barrels.

<table>
<thead>
<tr>
<th>Item</th>
<th>Single use p.a.</th>
<th>Reuse p.a.</th>
<th>Difference with reuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrels (number)</td>
<td>2,500,000</td>
<td>80,000</td>
<td>-2,420,000 barrels used</td>
</tr>
<tr>
<td>Ethanol (empty bottles)</td>
<td>0</td>
<td>18,534</td>
<td>+18,534 bottles used</td>
</tr>
<tr>
<td>Barrels (kg) @3.3g weight/Barrel</td>
<td>8,250</td>
<td>264</td>
<td>-7986 kg plastic waste generated</td>
</tr>
<tr>
<td>Ethanol bottles (kg) @50.3g weight / bottle</td>
<td>0</td>
<td>932</td>
<td>+932 kg plastic waste generated</td>
</tr>
<tr>
<td>Total plastic (kg)</td>
<td>8,250</td>
<td>1,192</td>
<td>-7,058 kg plastic waste generated</td>
</tr>
<tr>
<td>Cost of barrels ($62.68 / 1000) + Ethanol ($3.2433 / bottle)</td>
<td>$156,700</td>
<td>$65,125</td>
<td>-$91,575</td>
</tr>
</tbody>
</table>

Table 3. Environmental and cost savings associated with recycling vacutainer barrels
Figure 3. Reduction in power usage by Coffs Harbour Laboratory

Figure 4. Coffs Harbour Laboratory water usage after move to new site (October 2008) with tank water

Figure 5. Taringa water usage after tank installation

Figure 6. Number of SST tubes used per patient episode.

Figure 7. Plain paper usage and cost.

Figure 8. Plastic specimen bag usage numbers
Discussion

Laboratories are often required or voluntarily undertake to implement some form of quality improvement program which may be of the form of ISO 9001, ISO 15189, ISO 14001 or Lean. Many of the core concepts of these programs interrelate. SNP is working towards an integrated management system, encompassing Lean, Safety, Environment and Quality. For example, a major aim of an EMS is to “prevent pollution”. Our Safety Management Systems already included a suite of policies and procedures relating to Emergency Preparedness and Response (e.g. fire safety, chemical handling and storage, spill kits, emergency procedures, etc.). Some benefits of an EMS include the reduction of waste (physical and process related), increases in efficiency, and associated cost reductions. These concepts and outcomes are integral to Lean engineering.

Annex B of the ISO 14001 standard identifies broad technical correspondences between ISO 14001 and ISO 9001. The fact that SNP already had an established QMS, combined with commonalities seen between the two standards (e.g. document and record control, audit process, non-conformities, management review, PDCA process, concept of continual improvement, etc.) aided the implementation process. Achieving certification ensured that SNP had addressed all requirements for documentation and processes fundamental to an environmental management system.

Conclusion

An organisation undertakes Certification to an EMS in order to introduce a structured approach for identifying and managing legal obligations, its environmental impacts and to meet key stakeholder aspirations. The benefits of the established EMS to the organisation have been improved environmental awareness and performance, cost savings, business efficiencies, compliance with regulations, improved corporate image, marketing opportunities, reduced risk of disaster and improved relationships with the public and community.

The EMS increases the accountability of both internal (staff, contractors) and external (patients, referrers, community). Importantly, it entrenches the concept of continual improvement in the minds of those stakeholders.

Implementing an EMS has led to improved environmental awareness and performance, improved relationships with the local community, environmental and real cost savings, as well as a leaner and greener approach to business. Since the implementation process began, SNP has seen a cultural change, with Environmental Management being at the forefront of many business decisions.

The pay back cost in terms of the implementation cost for ISO 14000 has been estimated at between 18 and 24 months (Quality Digest 2012) in other industries. To determine the payback period is difficult as a number of facility changes such as plumbing and power occur opportunistically and incrementally. The cost of implementation therefore is based on staff time spent on documentation and training and obvious costs associated with the implementation. The payback period in a clinical laboratory is estimated to be two years with substantial ongoing savings as well as the intangible benefits of greater environmental awareness and leadership.

Acknowledgements

We wish to thank the Executive and staff of Sullivan Nicolaides Pathology for their support and commitment to implementing these changes, particularly Peter Hobson, Toby Barker, and staff of the Coffs Harbour and Grafton laboratories.

References


Efficient haematology testing through hardware and software automation

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2Abbott Diagnostics PathWay Consulting Group, Asia Pacific

Abstract

The diagnostic pathology industry is experiencing increased pressure to provide consistent, high quality and rapid results. This pressure is compounded with providing an improved service whilst meeting tough financial constraints and overcoming a skilled staff shortage. PathWest Laboratory Medicine, Western Australia undertook a review of its core laboratory processes to cope with these demands. This led to acquisition of new instrumentation, introduction of an informatics package and automation and the modification of laboratory processes. This has resulted in improved services whilst reducing cost and reliance on staff without sacrificing quality.

Keywords: haematology, automation, informatics

Introduction

PathWest Laboratory Medicine services is comprised of a network of 25 laboratories across the state of Western Australia. The Royal Perth Hospital (RPH) is a major site within this network. RPH is an 833 bed acute-care hospital providing trauma, transplant, burns treatment, haem-oncology and oncology services. The department currently performs approximately 800 full blood counts (FBCs) per day and operates 24 hours per day, seven days per week.

The population of Perth has increased from 1.5 million residents in 2005 to 1.7 million in 2010 and at the same time there has been a shift to an older demographic (ABS 2011). These changes have resulted in increased work for pathology. Between 2008 and 2010 the routine haematology laboratory experienced a 6% annual increase in workload. As the workload increases the laboratory is also faced with an aging workforce, skills shortage and budget constraints.

Due to the increased workload PathWest tendered to acquire new instrumentation, with a goal to also improve the laboratory services and improve efficiency.

This resulted in the implementation of the following equipment between late 2007 and 2010:

1. Equipment upgrade to CELL-DYN Sapphire (Abbott Diagnostics, Santa Clara, CA, USA) haematology instruments (November 2007)
2. Smart information technology with OmniLab srl AMS Haematology informatics package (April 2009)
3. Automation hardware with a PathFinder 350S tube sorter (Aim Lab Automation Technologies Queensland, Australia) (September 2010).

The success of implementing the new equipment was measured at three points using time and motion studies and review of LIS data. Metrics were reviewed after the implementation of the CELL-DYN Sapphire systems, the informatics package and then the PathFinder 350S. Turn around time (TAT) metrics, labour time, autovetification rates and film review percentage were measured to quantify the improvements.

Materials and methods

A time and motion study was completed to evaluate the impact of the installed hardware and software systems. Data points were gathered from on-site observations and one week extracts of data from the laboratory information system (LIS). Results were measured at three stages:

• baseline solution (November 2007 to March 2009): CELL-DYN Sapphire systems interfaced directly to the LIS.
• new solution stage 1 (April 2009 to September 2010): CELL-DYN Sapphire systems interfaced to AMS Haematology informatics package
• new solution stage 2 (October 2010 to present): CELL-DYN Sapphire systems interfaced to AMS

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haematology informatics package combined with Pathfinder 350S.

Changes to the laboratory and the metrics measured;

1. **Equipment upgrade - CELL-DYN Sapphire haematology instruments**

   The setup of the Routine Haematology Department in April 2007 consisted of two Abbott Laboratories CELL-DYN 4000 haematology analysers and an Abbott Laboratories CELL-DYN SMS automated slide maker stainer. In November 2007, the CELL-DYN 4000 analysers were replaced with two CELL-DYN Sapphire analysers.

   The department was staffed by a team of 7.4 full-time equivalents (FTEs) comprising medical scientists and technicians. Over the duration of the study period the total number of haematology staff remained static at 2007 levels, despite a 23% increase in haematology testing volume between 2007 and 2010, from 650 FBCs to 800 FBCs per day.

   Metrics measured to gain accurate baseline picture (all metrics were generated using LIS extracts for urgent and routine FBC samples collected over a seven day period including weekends);

   - **% film review rate**
     This was measured as the percentage of films generated from the number of FBC tests ordered. This includes films for morphology review and manual differential. Metrics are calculated from LIS data.

   - **% verification rate**
     The percentage represents the number of results that were automatically released and validated by software systems without any human interaction. This was calculated using LIS and informatics package data extracts.

2. **Smart information technology - AMS Haematology informatics package**

   In order to improve the post-analytical process, in April 2009 the AMS Haematology informatics package was installed. This allowed test result auto-verification rules to be implemented. As a baseline the International Society for Laboratory Haematology’s consensus morphology guidelines were used to create the primary rule set (ISLH 2009).

   The hospital has a large patient population with abnormal but stable results. The laboratory implemented rules based on assay reference ranges, as well as delta checks against previous results. The reference range intervals were set at slightly wider than the accepted normal range. The time limit for delta checks was set at 35 days in order to accommodate results from patients with monthly hospital visits. All rules were approved by the haematologists before implementation.

   The impact of the informatics package and the CELL-DYN Sapphire systems was evaluated using the same metrics (% film review rate and % auto-verification rate) and time frames as per the base line data collection.

3. **Automation hardware - PathFinder 350S automated tube sorter**

   In September 2010, the routine haematology department installed the PathFinder 350S. The PathFinder 350S is a bench top tube sorter that automates the routing and tracking of samples through the testing process. The PathFinder 350S is utilised for post-analytical sorting and archiving after haematology samples are run on the CELL-DYN Sapphire analysers. The following hierarchical order for the customisable sorting locations on the PathFinder 350S was implemented:

   1. Error position (samples where the bar code label cannot be read or no tests have been ordered)
   2. CELL-DYN Sapphire (samples awaiting FBC results, or samples with repeat tests or reticulocyte counts)
   3. CELL-DYN SMS (samples requiring a blood film)
   4. Other haematology testing (samples with sedimentation rates or malaria screens)
   5. Biochemistry (haematology samples with additional biochemistry tests)
   6. Archiving (samples with all tests complete)

   The impact of the PathFinder combined with informatics package and new analysers was evaluated using the following key metrics (all metrics were generated using LIS extracts for urgent and routine FBC samples collected over a seven day period including weekends);

   - **FBC median TAT**
     The median TAT for FBC sample completion is calculated using the LIS data.

   - **Australian Council on Health Standards KPI measurement**
     (number of FBC released within 30 minutes and within 60 minutes of sample collection)

   Laboratories across Australia are measured against the Australian Council on Health Standards (ACHS 2011). A key performance indicator that laboratories are required to measure is the time taken from sample collection to reporting of the haemoglobin result for patients presenting to the emergency department. At RPH the proportion of urgent FBC sample requests reported within 30 minutes of collection is monitored. The number of routine FBC
samples reported within 60 minutes is also reviewed regularly. The changes in these metrics were reviewed using LIS data.

**Median FBC TAT per hour (over a 24 hour period)**

The TAT of FBC samples received per hour over a 24 hour period is measured using LIS data. The median TAT may vary for reasons of workload, sample arrival patterns and staffing levels. Measuring the median TAT per hour determines if the implemented solution provides a consistent TAT for FBC samples at all times across a 24 hour day. Consistency of TAT allows for predictability in result delivery to clinicians and can highlight process bottlenecks that require review.

The median TAT per hour was calculated utilising one week of LIS data. Data for urgent and routine samples is combined.

**Labour time**

At peak period in the morning two hours of one laboratory technician’s activities were observed and timed. This was done at the solution stage 1 and solution stage 2 to demonstrate the direct impact of the PathFinder 350S on labour.

**Results**

**New solution stage 1: Smart information technology - AMS Haematology informatics package**

**Metrics 1 & 2: Film review rates and auto-verification rates**

The implementation of the CELL-DYN Sapphire systems combined with the AMS Haematology informatics package resulted in a 27% reduction in the blood film review rate. Table 1 illustrates that blood film reviews declined from 22.9% of total samples to 16.7% of total samples after the implementation of the CELL-DYN Sapphire and AMS Haematology informatics package. In March 2011, the percentage of sample results released directly to clinicians reached 55%. With continuous refinement of the rules the auto release rate will further increase.

Figure 1 displays the reduction in film review rate between January 2008 and March 2011.

This demonstrates a gradual decline in film review rate as auto-verification rates are continually refined as confidence in the rules and analyser technology is gained.

**Table 1:** Auto-verification and film review metrics

<table>
<thead>
<tr>
<th>Percent blood film</th>
<th>Percent results auto-verified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline solution (January - June 2008)</td>
<td>22.9%</td>
</tr>
<tr>
<td>New solution (January - March 2011)</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

**Table 2:** Routine and urgent FBC median TAT and % complete within goal time frame

<table>
<thead>
<tr>
<th>Routine FBCs</th>
<th>Urgent FBCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median TAT – receipt to result (minutes)</td>
<td>Median TAT – receipt to result (minutes)</td>
</tr>
<tr>
<td>Complete within 60 mins of collection</td>
<td>Complete within 30 mins of collection</td>
</tr>
</tbody>
</table>

| Baseline solution (CELL-DYN Sapphire, LIS) | 41 min | 74% | 19 min | 9% |
| Solution stage 2 (CELL-DYN Sapphire, AMS Haematology informatics package, P350S) | 24 min | 86% | 14 min | 83% |

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Figure 2. Pie chart representation of time devoted to haematology staff labour pre and post PathFinder 350S implementation. Time is represented in hours:minutes:seconds. SMS = slide maker stainer.

New solution stage 2: Automation hardware - PathFinder 350S automated tube sorter

FBC sample processing prior to the introduction of the PathFinder 350S included manual accessioning, checking for other tests and sorting tubes. Manual post-analytical sorting has been largely removed with the introduction on the PathFinder 350S. Manual interaction steps were reduced significantly and this is represented in the stage 1 and stage 2 flow charts in Fig. 5.

Metric 1 Labour time

Installation of the PathFinder 350S resulted in a significant reduction in the amount of time the technician spends locating and sorting tubes. This is evident in the reduction of approximately 50% of time spent for the following three activities: archiving samples, locating tubes and sorting tubes for presentation to the automated CELL-DYN Slide Maker Stainer (SMS). The PathFinder 350S now sorts the tubes into a rack for SMS processing.

The change in work process with introduction of the PathFinder 350S has allowed for the staff to focus more time on running the Sapphire systems, review results and time to complete other tasks. This is demonstrated in Fig. 2. This has contributed to the improvement in the TAT.

Metric 2: Median TAT

The median TAT for routine samples was 41 minutes at the baseline solution (CELL-DYN Sapphire systems interfaced directly to the LIS). After the implementation of software and automation systems, the median TAT improved by 39% to 25 minutes. The median TAT for urgent samples was reduced by 66% from the baseline solution once the informatics package and PathFinder 350S were installed. This resulted in a decrease of the median TAT for urgent samples from 56 minutes to 19 minutes. This is demonstrated in Table 2.

Metric 3: Australian Council on Health Standards KPI measurement (number of FBC released within 30 minutes and 60 minutes)

There was a marked improvement of over 800% in the number of urgent FBC tests completed in 30 minutes. The number of urgent FBC samples where results were reported within 30 minutes increased from 9% to 83% after the introduction of informatics package and the PathFinder 350S.

The number of routine FBC tests completed and reported within 60 minutes improved by 12% from 74% to 86% of all routine FBC’s.

The FBC completion rates are shown in Table 2.

Metric 3: Median TAT per hour

The introduction of informatics package and PathFinder 350S resulted in a reduction in the median TAT for the peak periods of the day between 6am and 5pm.

The median TAT per hour prior to implementation of the informatics package and PathFinder 350S show a variability of 41 minutes. The lowest median TAT per hour was 9 minutes at 3am. The greatest median TAT per hour was 55 minutes at 8am. The new solution reduced the variability in median TAT per hour by 39% to 25 minutes, for example the median TAT at 8am is decreased from 55 minutes to 31 minutes. Median TAT per hour is illustrated in Fig. 3.

The TAT was impacted by both the installation of the middleware and the PathFinder as demonstrated in Fig. 4.

Discussion

This study evaluated the impact of installing smart information technology in the form of a flexible rules based informatics package and automating routine tasks with PathFinder 350S.
Significant improvements in TAT statistics are a result of improved processes combining CELL-DYN Sapphire technology with AMS Haematology informatics package and the PathFinder 350S automated sorter. The combination of these elements has allowed for reduction in manual tasks (see Fig. 5) which has resulted in consistent handling of samples and the ability for the laboratory to provide an improved service despite the increase in workload.

The reduction of manual tasks achieved through smart information technology and automation of laboratory processes has allowed containment of the laboratory’s greatest cost staff. The level of full time employees has been maintained at a static rate despite consistent growth in the workload. This static rate has been achieved in haematology and across the whole core laboratory as a result of technology and process changes across the laboratory.

Film review and auto-verification rates

The significant reduction in the film review and auto-verification rates was achieved through the ability to create comprehensive rules in the informatics package. Informatics package software such as AMS Haematology provides an automated pathway of analysing clinical algorithms that are developed, refined and then adopted based on the results derived from the analyser technology. The ability to create rules on any data element in AMS Haematology permits rules to be highly complex. The capacity to use multiple system results, patient demographics and calculated data provides unlimited opportunity to enhance these rules further.

FBC results were previously manually reviewed in the CELL-DYN Sapphire software. The operator decided whether a film was required, and if so, added the sample

Figure 3. Median routine TAT by hour of the day. Data collected over a similar Monday to Friday five day period in April 2008 and March 2011.

Figure 4. Impact of AMS Haematology and Pathfinder 350S on TAT. The number of full blood counts is the average daily number performed Monday to Friday for that month and the mean TAT is based on the analysis of a single continuous 5 day period Monday to Friday for the same month.
to the film work list. This was a time consuming task, and also quite subjective depending on the skill level of the laboratory technicians. The subjective nature of manual result review led to inconsistent handling of patient results. As a consequence films were either made in excess or missed. The extensive rule set in AMS Haematology allows consistent handling of samples. This has greatly improved TAT and accuracy of work, and reduced the total manual processing required.

Film review and automated verification rules that have been implemented using AMS Haematology are also a function of the instrument technology. The CELL-DYN Sapphire systems offer a first pass optical platelet count and nucleated RBC count, and this combined with clever white cell technology allows more samples to be released without human intervention (Muller et al. 2006). Comparison studies of CELL-DYN Sapphire with Advia 120, Coulter LH750 and Sysmex XE-2100 show CD Sapphire has the highest efficiency rate for clinical usefulness in morphological classifications (Kang et al. 2008). This enables confidence in releasing system generated results without manual intervention.

RPH aims to further develop the range of auto-verification rules in AMS Haematology. Future rules will evaluate the Sapphire flagging confidence indices, patient clinical condition and clinical history. It is expected that the introduction of these rules will allow a further reduction in film review and an increase in autoverification.

**Reduction in TAT**

There was a marked improvement in TAT consistency with the introduction of the informatics package and automation. The reduction in the median TAT per hour demonstrated the solution has reduced the variability of TAT throughout the day. Spikes in workload over the course of the day beyond the control of the laboratory remain; however impact on TAT is not as marked as with the baseline solution.
The TAT data demonstrates that there was a significant decrease in TAT after the informatics package was installed. This trend continued after the PathFinder 350S replaced manual tube sorting. This is demonstrated in Fig. 4. The continued improvement post installation of the PathFinder 350S is indicative of the systems ability to provide early detection of missed tests. This has resulted in staff time being redirected to tasks that directly impact on result generation. Previously missed tests led to outliers which negatively impacted the median TAT and TAT per hour. The reduction in TAT of both the routine and urgent samples is also partially due to further refinement of informatics package rules that took place between April 2009 and September 2010.

The PathFinder 350S allowed the rapid detection of samples that incorrectly bypassed initial testing on the CELL-DYN Sapphire analysers. In addition, it also identified samples that had been incorrectly registered by data entry. This early detection reduced prolonged outlying turnaround times and ultimately improved patient outcomes.

Between 10pm and 5am the bulk of sample registration is completed by the haematology shift worker. The reduction of manual processes including sorting and accessioning tubes has resulted in faster specimen reception during this time, improving TAT for the entire core laboratory.

Samples were previously manually sorted to the required testing locations. For accountability, they were placed in the sorting rack according to bar code number. This was complicated by the laboratory’s use of two sets of bar code numbers. The staff member sorting the samples needed to ensure the samples were placed in the correct rack, in addition to the correct slot within the rack. By using the PathFinder 350S to sort all samples, this source of confusion and error has been eliminated.

The default PathFinder 350S racks are suitable for long-term sample archiving. Completed samples can move directly from the PathFinder 350S into refrigerated storage. The PathFinder 350S also maintains a database of the precise location of all samples.

Conclusion

This study has demonstrated how improved work process, combined with software and hardware automation, can assist a busy, resource constrained laboratory to adapt to increasing workloads while improving the quality of service delivered. The implementation of the new CELL-DYN Sapphire systems with informatics package and automation has successfully met the goals of improving laboratory services and enhancing efficiency. The laboratory management believes the FBC TAT is now equal to other internationally recognised centres of excellence.

As laboratories continue to come under pressure to achieve more with less, focus has been removed from scientific technology and redirected to automated processing. This study provides an example of how analytical technology combined with automation of processes provides greater efficiency.

A low TAT will be achieved with highly accurate and precise technology that allows the analyser to complete sample analysis without human interaction. First pass reportable results allows for less manual intervention steps and system reruns. Automated analyser systems may be able to generate fast results; however if the result is of an inferior quality level and requires human intervention the TAT will be increased.

Over the last five years (at least) analyser technology has become less of a driver in analyser decisions due to greater focus on automation. In Australia this has been evident by the cessation of analyser head to head evaluations. This study has demonstrated that TAT and labour efficiency benefits can be achieved through various types of automation. The analyser technology however can be a limiting step in maximising efficiency, and medical scientists should invest more time in understanding how specific instrument technology can improve efficiency and clinical service delivery.

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References


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The implementation of a Quality Management Information System (QMIS), utilising Q-Pulse Quality Management Software, has allowed us to develop an integrated Quality Management System (QMS) across our 19 laboratories. This development has led to significant efficiencies in SA Pathology including a reduction in the number of standard operating procedures, reduction in audit workload and a reduction in annual cost savings.

Ruth Salom
Executive Director
SA Pathology

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An eight-year-old child presented to the Children's Emergency Department with bloody diarrhoea. A full blood count and coagulation studies were performed. Chemistry and microbiology tests were also performed.

The haematology results were as follows:

- **Hb**: 76 RR 113-143 g/L
- **HCT**: 0.205 RR 0.33-0.41
- **MCV**: 77.1 RR 75-86 fl
- **MCH**: 28.6 RR 25.7-30.6 pg
- **WBC**: 7.5 RR 4.7-12.2 x 10⁹/L
- **PLT**: 21 RR 187-415 x 10⁹/L

Coagulation studies:

- **PT**: 17.1 RR 12.1-145 sec
- **INR**: 1.3 RR 0.92-1.14
- **APTT**: 39.0 RR 32.5-43.8 sec

The haematology results showed anaemia with a marked thrombocytopenia. The blood film showed a microangiopathic haemolytic anaemia with moderate numbers of schistocytes. The neutrophils showed toxic granulation and a slight left shift with an occasional myelocyte.

The raised urea and creatinine on this child indicate ‘acute renal failure’. Microbiology results were as follows: *Shiga* toxin/verotoxin-producing *Escherichia coli* isolated.

The child was diagnosed with haemolytic uraemic syndrome (HUS). The schistocytes seen on the blood film represent red cells that have been physically damaged or ripped whilst passing through narrow sclerosed vessels within the kidney. The term schistocyte comes from the Greek word ‘skiss’ which means to ‘rip’. Schistocytes are a characteristic red cell found in microangiopathic haemolytic anaemias.

In 1924 Moschcowitz described the first case of an adult with a microangiopathic blood picture which was labelled ‘thrombotic thrombocytopenic purpura’ (TTP). Thirty years later, in 1955, Gasser *et al* described the first case of a child with a similar blood picture but with different clinical symptoms. The child was described as having ‘haemolytic uraemic syndrome’ (HUS). Although the blood films in both TTP and HUS are identical, the clinical symptoms differ as does the treatment. The TTP-HUS syndrome is characterised by thrombocytopenia, microangiopathy, fever, renal abnormalities and neurological changes. The neurologic changes characterise TTP while the renal abnormalities, namely glomerular damage, especially in children, is characteristic of HUS although some cases of TTP may present with mild renal dysfunction.

The peak incidence of HUS is between six months and four years of age. There are two types of HUS, namely, D+HUS involving diarrhoea and D-HUS or atypical HUS which does not present with diarrhoea. D+HUS is the classic form of HUS occurring in 95% of children. The children present with bloody diarrhoea secondary to infection with *E. coli* 0157:H7 bacterium which produces a *Shiga* toxin. This toxin enters the circulation via the gastrointestinal mucosa. It localises in the kidney causing endothelial cell injury leading to cell necrosis and apoptosis. The coagulation cascade is activated. Platelets are activated and micro thrombi are formed. This whole process results in sclerosed, narrow vessels within the kidney. As the red cells pass through these narrow vessels or as they pass across a strand of fibrin placed across the damaged narrow vessel, they are physically ripped or sheared off resulting in a microangiopathic blood picture. This process culminates in severe glomerulonephritis and acute renal failure.

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D-HUS accounts for the remaining 5% of cases of HUS and is associated with complement activation. Some examples of D-HUS include viruses (HIV), malignancy (disseminated adenocarcinoma of the prostate, stomach and pancreas), medications (mitomycin C), pre eclampsia or HELLP (haemolysis, elevated liver enzymes and low platelets), post bone marrow and stem cell transplantation (cyclosporine) and other underlying conditions such as scleroderma.

Patients with TTP present with the classic pentad of microangiopathic haemolytic anaemia, thrombocytopenia, neurological symptoms, fever and in some cases, mild renal dysfunction. The mechanism leading to TTP does not involve endothelial cell injury but rather a deficiency in the protein ADAMTS-13 which regulates von Willebrand factor. Lack of ADAMTS-13 induces platelet aggregation and the formation of microthrombi throughout the microvascular system, especially in the heart, brain and kidneys.

**Treatment**

Treatment of HUS begins with early recognition of the disease. Children who have had oligoanuria for less than 24 hours usually respond well to fluid and electrolyte balance. Antibiotics increase the release of Shiga toxin from the *E. coli* O157:H7, exacerbating the haemolytic uraemic syndrome and should be avoided. A microangiopathic blood picture in the laboratory is a ‘medical emergency’. The haematology morphologist must be ever vigilant when a child presents with anaemia and thrombocytopenia and has a history of diarrhoea.

**References**


An innovative QMS integration of 19 laboratories in South Australia

Jason Graefling, Pamela Fagan, John Sweeney and Ruth Salom
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Objective

To develop an integrated Quality Management System (QMS) for the single state pathology service known as South Australia (S.A.) Pathology utilising a Quality Management Information System as a framework, and catalyst, for its creation. SA Pathology was formed in 2008 and incorporates some 2000 staff across 19 laboratories in metropolitan Adelaide and regional South Australia. Through the formation of SA Pathology the service inherited multiple diverse quality frameworks which needed to be aligned.

Method

In 2011 SA Pathology commenced the development of a consolidated QMS across all laboratories to align disparate processes and thus improve efficiencies, effectiveness, and local ownership with centralised oversight. The framework for this development was the introduction of a Quality Management Information System (QMIS), utilising Q-Pulse Quality Management System software.

Background

SA Pathology provides pathology services through a networked system of 19 laboratories, consisting of seven fully comprehensive 24/7 laboratories in large metropolitan hospitals (Royal Adelaide Hospital (RAH), The Queen Elizabeth Hospital (TQEH), Flinders Medical Centre (FMC), Women's and Children's Hospital (WCH), Lyell McEwin Hospital (LMH), Repatriation Hospital (RGH), Modbury Hospital) and twelve branch laboratories in rural hospitals. Prior to this project most laboratories ran semi-independent QMS's with minimal overarching framework.

The development project was implemented by Health Care Informed (HCI) and commenced with senior management project planning, process mapping, re-engineering and standardising key quality processes including process control, audit management, non-conformances and staff training. The overall aim was to create an overarching QMS structure which could then be locally managed, and centrally monitored, via the QMIS. Based on this work, the Q-Pulse system was configured to maximise efficiencies brought about by the system itself and the newly reengineered, and standardised, quality system processes.

Following this stage of development an extensive staff training programme was implemented across S.A. Pathology. In addition the system go live was supported by a staff communication and marketing campaign to assist buy in and understanding.

Results

The project achieved its overall aims and objectives. The predominant outcome from this project is that SA Pathology has a consolidate QMS, which utilised a Quality Management Information System as both a framework, and catalyst for its success. The project in itself also consolidated the working relationships between the various discipline staff at the 17 locations within the single state pathology service.

This development resulted in significant efficiencies in the operation of S.A. Pathology's Quality Management System including:

• Reduction in number of Standard Operating Procedures: 4,500 (>50%)
• Reduction in audit workload: 7,170 Hours (>70%)
• Estimated annual cost savings (SOP development/review and audit time) > AUD $300,000

Conclusions

The consolidation of Quality Management Systems across organisations is not only possible but highly beneficial. The results demonstrate that this form of consolidation project, properly implemented, can result in a centralised, co-ordinate system which maintains strong local ownership, and result in significant cost savings. The utilisation of a Quality Management Information System provides both a framework, and catalyst for the improvements in quality as well as consolidating the implementation of a single state pathology service.

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Time to redefine the requirements for a medical laboratory scientist

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Introduction

Medical laboratory scientists sit at a crossroads in terms of recognition and role definition. It has been documented that there is a lack of recognition of the profession and the role it performs and that there are “still significant barriers to the achievement of true professional status for medical scientists” (McGregor 2003). Furthermore McGregor found medical science was the second choice for almost 10% of her survey respondents and 32% of respondents indicated they would not choose medical science if they had to make a career choice again. There are a number of reasons for this including the public confusion with the title “medical scientist”, the lack of cohesion in the profession and the lack of identity of many medical scientists. There are major changes occurring in medical laboratories which are challenging the traditional tasks, training and the role boundaries between medical scientist (medical laboratory scientist) and medical technician (medical laboratory technician). The purpose of this article is to argue that change in the education and training of medical scientists is essential, to suggest what changes should occur and how these will support the future role of the medical scientist.

Supply and demand of medical scientists

There are conflicting reports about the supply of medical scientists. The Urbis Survey reported shortages (Urbis 2011), but the analysis within the Human Capital Alliance (HCA) Report (Human Capital Alliance 2011) suggested an oversupply of medical scientists in some areas, although there are undoubtedly specific locations and disciplines where there are shortages. These shortages often occur at state boundaries where different remuneration across borders distorts the true picture. To add to the problem, there are many new medical laboratory science degree courses about to commence which will add to the current high levels of graduates. This increased supply has already reinforced the distortions in the work force boundary so that scientists are employed in technician’s roles, either as an ‘internship’, or to increase the “flexibility” of the work force (Human Capital Alliance, 2011). The organisational establishments of many laboratories also introduces a ceiling at 8-10 years post graduation, where graduates cannot progress without a position becoming available and consequently most staff structures are characterised by flat, bottom heavy, staff pyramids (Human Capital Alliance, 2011). However evidence gathered by Human Capital Alliance does not support the contention that there is a wastage of experienced scientists even though this is often voiced by the industry. In fact their report stated that “the problems identified ... manifest not so much in higher occupational wastage rates but rather in lower productivity of poorly motivated workers” (Human Capital Alliance, 2011).

There is however an impending retirement bulge in the workforce in Australia which will probably lead to a deficiency of staff. It has been estimated that up to 50% of the current US laboratory directors will retire in the next decade and it is possible that a similar exit may be seen in Australia (NPAAC, 2007). Thus it is likely that the greatest shortages in the medical laboratory in the future will be felt at levels where there is the need for the highest skill and experience, that is at the level of expert scientist (NPAAC, 2007) and laboratory director (Scott 2012).

Changes in practice in medical laboratories

There have been many changes in medical technology and healthcare delivery systems, particularly in terms of range and numbers of medical (diagnostic, screening and monitoring) tests performed outside of hospitals and in the community, yet medical scientist training has not really reflected these changes.

With the ageing population, the increasing burden of chronic disease, newly emerging diseases, the complexity of modern medicine, and the development of newer molecular diagnostics and treatment options, it is clear that more medical testing will be performed in the future. There will be continuing advances in automation in all disciplines, as well as significant increases in genetic and molecular testing, and there will be a greater use of more sophisticated point-of-care testing (POCT) technology. Some conventional testing will cease, such as the PAP smear, as the benefits of HPV vaccination become apparent.
One possible and likely scenario is that the laboratory service of the future will consist of larger central laboratories supported by a wide range of networked POCT devices. In part due to the continual development of automated instrumentation, many of the current tasks performed by medical scientists will be performed by less formally qualified staff, and the role of relatively fewer scientists will be the management of the POCT and central network, the optimisation of workflow, performing complex analysis, probably with a molecular basis, the interpretation of complex results and the implementation of evidence based laboratory medicine.

It has been argued that the traditional disciplines will have coalesced into three broad areas, blood sciences (clinical chemistry, haematology, immunology, transfusion, automation), cell science (histopathology, cytology, cytogenetics) and infection science (microbiology, infection control, epidemiology) (Beck 2008).

What is critically important for the future is that mechanisms need to be put in place that allow for continual workforce planning to reflect these changes.

Relationship of medical scientists to other laboratory staff

As a consequence of these changes in practice and technology many of the tasks that were once deemed complex are now seen to be routine. Murray has reported that many medical scientists are becoming deskilled by the environmental changes occurring in laboratories as ‘core’ labs are created (Murray 2009). This deskilling is happening because there is no longer the requirement for scientists with high level skills in many laboratories. They were also able to show, albeit in a small sample, that despite some reservations about the length and level of supervision given to graduate level scientists, those graduate scientists did not believe they were any less capable than the single discipline scientist. This suggests there is no longer a need to have as many scientists in laboratories. Indeed part of the boredom and frustration felt by medical scientists is because of the lack of a real challenge in their work. The boundaries between scientist and technician have always been somewhat blurred, but this has increased rather than decreased (Beck 2008, McGregor 2003). This confusion begins at the tertiary institutions where to a large extent university and TAFE college course co-ordinators “perceive that upon graduation, their degree and diploma graduates as having similar skills when they enter the pathology workforce” (Streitberg 2010). The degree does provide a greater understanding of disease and analytical processes but as Streitberg states, this “does not translate into perceived different work capabilities” (Streitberg 2010). In fact in many laboratories there is no clear differentiation between the roles of scientist and technician. Some employers have recognised these changes in the workplace and are employing relatively more technicians than scientists. Thus a scientist vacancy will be often be replaced by a technician (Human Capital Alliance 2011).

The future role of medical laboratory scientists

Whilst predicting the future is obviously speculative, it is possible to suggest the broad areas where medical scientists may find themselves in a future lab, perhaps up to 2020. The laboratory of the future will be under greater financial and demand pressures, consequently there will be a need to ensure the maximal use of available resources. Demand management will involve the following:

• Reducing underutilization of laboratory testing through greater adoption of guidelines and evidence based medicine to ensure that patients receive appropriate and timely care
• Manage overutilization through reducing inappropriate or unnecessary laboratory testing
• Participate in improving chronic care management through proper use of clinical laboratory testing, leading to improved patient compliance and fewer episodic events.
• Eliminate those laboratory tests that offer little clinical value and those lab tests which are ineffective or obsolete.

To meet the challenge of these management imperatives, it will be essential to have highly trained staff who can critically evaluate current and potential tests, modify requester demand by the production of accessible guidelines, and manage the operations of a laboratory network as efficiently as possible. These management and consultation competencies need to be built into the future training processes for the clinical scientist and laboratory manager. Accordingly the future medical laboratory scientist requires a solid foundation in biological science with an emphasis on cellular biology, anatomy, chemistry, microbiology, statistics, biochemistry, genetics, molecular biology and pathology. These should be at the level of the preliminary degree. The post graduate component should provide the necessary laboratory medicine subjects such as haematology, clinical microbiology, clinical chemistry, transfusion medicine, clinical genetics, molecular pathology and advanced pathology. Part of the problem that courses are currently having is that they are trying to achieve both a strong foundation in laboratory skills and a core knowledge in laboratory medicine.

In the face of these changes in the working and professional environment Medical Laboratory Science degree courses have also changed to some degree by for example, increasing the molecular biology components. However they have also reduced the number of contact hours and particularly the number of practical sessions, usually the basic chemistry practicals in the early parts of the
course. As a result many students come out of these degrees with poor basic laboratory skills in areas such as weighing, pipetting, performing calculations and other basic practical skills. In general the teaching of science based courses has become more theoretical and less practical, which has become an issue for applied science courses such as medical laboratory science.

Placement of medical laboratory scientists

The deficit in basic skills is being filled by professional placements where the students are sent to working laboratories for 6-9 months of laboratory exposure. This time is certainly advantageous for students and can be for laboratories as they have the opportunity to see potential employees in a working environment. However with more and more students moving into these courses the financial and human resources burden is becoming too great for laboratories to be able to sustain. At a time when many laboratories are contracting in size and scope, there are insufficient training placements available for potential students. Also the educational experience for students is different depending on the laboratory where they are placed. This places a burden on laboratories to undertake activities for which they do not have adequate expertise or resources.

There needs to be close links between universities and working medical laboratories to ensure access to knowledge and research opportunities, but a working laboratory does not provide the best learning opportunities. When there is not a clear cut advantage for a laboratory to train a student who is not likely to be employed in a laboratory there is no advantage to that laboratory. Indeed in this situation it is likely that the student will be seen to be a burden or a source of cheap labour.

Given all of the above what should be the content of courses in order to provide the theoretical and technical underpinnings of the future needs of the medical scientist?

Streitberg commented on the importance of work placements as a component of a medical laboratory science undergraduates training and how “preparedness for entry level work correlated strongly with the length of the professional placement” (Streitberg 2010). The problem with training placements for employers is the cost. It is intriguing that the same training is not an integral component of the course requirements for technicians and technical assistants. Despite the changes in laboratory workforce and the recognition of vocational training, the pathology sector has not yet fully embraced what the VET sector can offer. Apprenticeships and traineeships for aspiring technicians and technical assistants are strongly favoured in some sectors and have been shown to be of benefit in areas of work force shortages (Human Capital Alliance 2011). An apprenticeship also provides security and certainty for the employer that their resources are being effectively used. There is also financial support available for this training which would make it more attractive. A move towards better structured training for the technical staff would further obviate some of the concerns about upskilling of staff.

Postgraduate training

Once a graduate has entered the work force there needs to be further professional development as that graduate attains the knowledge and skills necessary to advance in an organisation. There are currently a number of possible pathways with the scientist either becoming an expert analyst or moving into an administrative role. Within the profession there is some frustration with the greater administrative demands of scientists (Human Capital Alliance 2011) and the fact that the management route is better renumerated. Formally a scientist can sit for one of the range of Professional Fellowships available which allow them to become a senior scientist (NPAAC 2007) and potentially supervise a department of a teaching hospital or equivalent. Few scientists travel this pathway, probably because of the difficulty and perceived poor rewards.

Other formal post graduate qualifications are the PhD or Masters, but it appears that more scientists pursue a Masters degree in management or administration rather than science, again because of the better career outcomes (Human Capital Alliance 2011). It has been recognised that a strong research grounding is essential for any person wanting to become a laboratory director with translational and/or clinical research being the most relevant areas of research. Recently the strategic thinkers of the American Association of Clinical Chemistry (Scott 2012) have suggested that the research component should be at least 30% of the training component of a clinical scientist. It must be conceded that a degree such as the Bachelor of Medical Laboratory Science which prepares graduates for a demanding vocation such as medical science does not allow for a strong research component as there is just insufficient time in the course. For those graduates who wish to move into research or train to become Clinical Scientists at some stage, the primary undergraduate degree does not equip them with the essentials to be able to undertake those potential career options.

A Masters of Medical Laboratory Science degree as a basic requirement

To be able to undertake these additional and different roles in the laboratory of the future perhaps we should plan for fewer medical scientists and require that they have a higher degree which would provide the additional skills we believe are required. Those skills include robust study/experimental design, ability to interpret data objectively and critically, assay development and validation and the development of a desire for innovation. These skills require
a change in the emphasis of education and a need to have a longer formal and vocational training period. The formal education requirements would involve a research component to develop those necessary skills in evaluation, some advanced training on clinical interpretation and the exposure of the student to management theory as it relates to clinical laboratories.

This change would require a complimentary upskilling of technicians to be able to perform most of the routine assays in a clinical laboratory. The role of the future scientist would then be as either a manager, trainer or expert analyst. We would therefore advocate that medical laboratory science should be a post graduate qualification to be undertaken by a cohort of more mature students who have already demonstrated good learning skills and who have demonstrated a willingness to undertake post graduate training. This self selection step may lead to a cohort of students with more motivation to remain in the profession and seek higher qualifications. It would raise the entry level of the profession leading to better recognition and ultimately, reward for those people with these additional and valuable skills.

Given the findings we described at the beginning of this article of a significantly unsatisfied profession, there is a need to consider a radically different education path than the current one and generate a different group of medical scientists. There is a broad movement towards the graduate-entry model in many professions reflecting an emphasis on teaching professional skills at an advanced, intensive level. The switch to graduate entry also allows for a greater diversity of applicants who are more mature and motivated to study at the professional level.

Conclusions

We have described a future laboratory that will have fewer scientists with a different skill set, such that the bulk of the technical tasks will be undertaken by associate degree or vocationally trained staff. This requires future medical laboratory scientists to commence their career with a higher degree to provide the newer skills that are required.

A Masters degree is a prerequisite for a number of other health care professions such as audiology, clinical psychology, orthoptics and is favoured for dieticians, medical physicists, radiographers, podiatry, physiotherapy

Following the attainment of a medical science degree, the subsequent career pathways for medical laboratory scientists would involve the attainment of a Fellowship from AIMS, AACB, HGSA, ASM or the RCPA which would equip the candidate to become a clinical scientist. These higher qualifications are demanding and require a highly motivated self-directed scientist with keen analytical skills. It could be argued that the poor uptake by people wanting to undertake these higher qualifications reflects the inadequate training of undergraduates entering the profession.

We should set out to build a professional base which will be sustainable and bring to pathology a core of highly skilled professionals with some experience in research who are capable of advancing in the profession.

References


Disclaimer

This article is the opinion of the authors and is not necessarily the opinion of the editors of the Australian Journal of Medical Science or of the Australian Institute of Medical Scientists.
Biochemistry for Health Professionals  
Laura Batmanian, Justin Ridge and Simon Worrall  
Mosby Elsevier  
Soft cover    305 pages  
ISBN 9780729538749  
AUD $100.00

The book is divided into five parts. The first part is Biological Chemistry and contains chapters on basic such as elements and compounds, water and organic molecules. These first chapter explains chemical bonding and electron shells.

The chapter on water includes acid base chemistry and buffers. A chapter on organic molecules includes hydrocarbons and their reactions.

The second part of the book deals with molecules of biological importance. The chapters in this section include lipids, amino acids and proteins, non-catalytic proteins which are the providers of structure and functionality, carbohydrates and nucleic acids. These chapters are more detailed and give clinical examples.

The chapter on non-catalytic proteins goes into haemoglobin and myoglobin structure as well as immunoglobulins and protein membranes. The diagrams on membranes are very clear and describe how the membrane proteins interact with other proteins. The clinical example is sickle cell anaemia.

The chapter on enzymes is physical chemistry but gives clinical examples such as the metabolism of ethanol in the liver and enzyme assays such as measuring blood glucose by using glucose oxidase and measuring the amount of hydrogen peroxidase produced to determine the initial glucose level.

The chapters on carbohydrates and nucleic acid are basic organic chemistry. They contain clear diagrams of these structures.

The third part of the book deal with cell biology. This section includes chapters on basic cell structure and function. The chapters are unifying principles of biology which goes into the characteristics of living organisms, homeostasis with negative and positive feedback.

A chapter of prokaryotes, viruses and eukaryotes describes bacterial and viral structure.

Biological membranes and transport goes on from the protein chapter to describe in detail transport across membranes and is followed up with a chapter on cellular communication.

The fourth part of the book, part D is on energy, metabolism and nutrition. Metabolism and its control has a very elaborate diagram with the metabolic pathways and their interaction. Nutrition and digestion describes what we need to eat in the way of proteins, water, vitamins and minerals.

The chapters on catabolism of macromolecules and energy generation and anabolic metabolism has diagrams of the pathways and cycles that we had to learn at university such as the glycolytic and TCA pathways.

Integration of metabolism into the whole body and specialised tissue metabolism was more clinically based and I found these chapters more interesting.

The last section is on molecular biology and genetics. It describes DNA, RNA and protein synthesis as well as DNA replication and cell division. Mutations and inheritance was described in an easy to understand way and gave some clinical examples such as Cystic fibrosis and Marfan’s syndrome.

There are 32 tables and 253 figures. The tables are easy to read and clearly laid out. The Figures are diagrams to illustrate major points.

At the end of most chapters there is a summary set out as a flow sheet and/or a clinical example.

There is also a web based evolve learning resource attached to this book. This online resource has features such as flash cards, animations, crosswords and examination preparation sections. There are also links to additional suggested reading.

The book combines basic chemistry, organic chemistry and biology with clinical examples of the topics being discussed. An example is the chapter on copying DNA, DNA damage and heritable disease has examples of hereditary diseases such as Marfan syndrome and Duchenne muscular dystrophy. It does not attempt to list
hereditary diseases but just gives a couple of examples. It is not a medical text but a book for students beginning biochemistry. I would recommend the book as a good background to the basic concepts of biochemistry. It is not a clinical biochemistry book but does have some simple clinical examples to demonstrate principles being discussed.

It is easy to read and well presented. It would be an excellent student aid.

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Elsevier
Hard cover 239 pages
ISBN: 9780080456164
AUD $248.35

This atlas was a product of research funded by National Centre for Research Resources and Human Brain Project, National Institutes of Health, USA.

Since its introduction to clinical medicine, magnetic resonance imaging (MRI) has been a mainstay of brain imaging. In addition to detailed structural information of the central nervous system, MRI allows clear separation of gray and white matter of the brain and spinal cord. Building on the knowledge gained from MRI imaging, in vivo functional mapping has become sought after by researchers in to the great mysteries of the brain, as well as by clinicians investigating patients with neurological symptoms.

Visualisation and localisation of the communication pathways between different functional regions of the brain are pivotal to understanding complex behaviour, cognitive functions and neurological symptoms. Communication is maintained by white matter fibre bundles projecting from neurones in the gray matter. The aim of this atlas is to provide a three dimensional in vivo image of these numerous neuronal projections superimposed on the more conventional T1 weighted 2D images.

The atlas describes 3D reconstructions of 15 prominent white matter tracts in the cerebral hemispheres and 5 tracts in the brainstem. These tracts have been well described in classical neuroanatomy using cadaveric dissections and by functional studies on primates and human subjects with neurological dysfunction (strokes, tumours, traumatic injury to tracts). The technique used in producing the atlas is diffusion tensor imaging (DTI), a type of MRI.

Current practice in neuroimaging is to view the central nervous system in 2D images obtained in 3 different plains (sagittal, coronal and axial). The 3D reconstruction of the 2D images obtained in these 3 planes then occurs in the mind’s eye of the radiologist, neurologist or the neurosurgeon. It is a skill acquired with many years of experience and guidance. This atlas constructs the 3D images and superimposes them on the conventional 2D images obtained in the 3 traditional planes, so that the structures depicted can be related to images we are familiar with.

A picture is worth a 1000 words – this atlas brings home that truth. As medical students we spent many hours reading, re-reading and trying to commit to memory, thousands of words describing the neuronal pathways and connections in 3 dimensions. We looked at 2 dimensional images, read the descriptions and visualised them before dissecting the cadaveric brains. This atlas effectively reduces the hours of reading required to visualise the 3D images, by superimposing colour coded 3D reconstructions on the 2D images.

The images and illustrations are well presented, and I recommend this book to medical students, neurologists, neurosurgeons, radiologists and anyone with an interest in the wonderful, intricate, intriguing connectivity of the brain.

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1. Alzheimer’s Disease - Modernizing Concept, Biological Diagnosis and Therapy edited by H. Hampel & M.C. Carrillo. Karger. vi+194 pages


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Page 1 of 2

Questions relating to ‘Efficient haematology testing through hardware and software automation,’ page 82 of this issue.

1. The equipment upgrade resulted in median TAT reduction of 41 to 24 minutes for routine FBC and 19 to 14 minutes for urgent FBCs.
   True/False

2. The primary rule set for film review was established using the RCPA consensus morphology guidelines.
   True/False

3. The median TAT for FBC sample completion was calculated using the WIS.
   True/False

4. According to the Australian Council of Health Standards the key performance indicators for FBCs is the number of FBCs released within 30 minutes and within 60 minutes of sample collection.
   True/False

5. Introduction of the Pathfinder 350S increased the amount of post analytical sorting by staff.
   True/False

6. The improvement in FBC tests completed within 30 minutes was 800%.
   True/False

7. From figure 1 the linear trend line shows a reduction from close to 25% film review rate in January 2008 to a < 20% film review rate in March 2011.
   True/False

8. The highest median TAT is between 0700 to 1400 hours.
   True/False

9. Figure 5 shows reflex testing improvements between baseline and stage 2 solutions.
   True/False

10. The analyser used in the test paper was a CELL-DYN DIAMOND.
    True/False

Full Name: __________________________________________________________

Email: ______________________________________________________________

Please photocopy this page or print it from the electronic AJMS which is stored in the AIMS ‘Member centre’ under the heading ‘Journal’ at www.aims.org.au. Circle your answers then post, fax or scan and email to us by 31 November 2012 to:

AJMS APACE Questions, AIMS National Office, PO Box 1911, Milton Qld 4064. Facsimile: 61 7 3876 2999
Questions relating to ‘Serum uric acid and albumin levels and estimated glomerular filtration rate: Oxidative stress considerations’, page 90 of this issue.

<table>
<thead>
<tr>
<th>Question</th>
<th>True/False</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Uric acid has both antioxidant and oxidant properties, is excreted by the kidney and is associated with development of kidney disease. Albumin, another antioxidant is also excreted by the kidney in some renal diseases.</td>
<td>True/False</td>
</tr>
<tr>
<td>2. Serum uric acid levels progressively increased as eGFR decreased in both sexes in this study.</td>
<td>True/False</td>
</tr>
<tr>
<td>3. Decreased levels of serum albumin have often been ascribed to poor nutritional status but serum albumin level can also fall significantly in response to inflammation and capillary leakage.</td>
<td>True/False</td>
</tr>
<tr>
<td>4. Estimated GFR was calculated according to the Modified Diet in Renal Disease (MDRD).</td>
<td>True/False</td>
</tr>
<tr>
<td>5. Although hyperuricaemia has been proposed to be a major antioxidant, it has also been shown to be associated with the development of a number of diseases including kidney failure.</td>
<td>True/False</td>
</tr>
<tr>
<td>6. The aim of the statistical analysis was to define the strength of the relationship between eGFR, albumin and uric acid.</td>
<td>True/False</td>
</tr>
<tr>
<td>7. Decreased serum albumin levels were significantly associated with declining eGFR or serum uric acid levels.</td>
<td>True/False</td>
</tr>
<tr>
<td>8. Tables 1-3 show a decrease in serum albumin level which loosely correlated with a decline in eGFR.</td>
<td>True/False</td>
</tr>
<tr>
<td>9. Serum uric acid can function as a pro-inflammatory molecule with capacity to act as a pro-oxidant and as an antioxidant as well.</td>
<td>True/False</td>
</tr>
<tr>
<td>10. The study took into account existing conditions and medication.</td>
<td>True/False</td>
</tr>
</tbody>
</table>

Name: _________________________________________________________________________

Email: _________________________________________________________________________

Please photocopy this page or print it from the electronic AJMS which is stored in the AIMS ‘Member centre’ under the heading ‘Journal’ at www.aims.org.au. Circle your answers then post, fax or scan and email to us by 31 November 2012 to: AJMS APACE Questions, AIMS National Office, PO Box 1911, Milton Qld 4064. Facsimile: 61 7 3876 2999
<table>
<thead>
<tr>
<th>YEAR 2012</th>
</tr>
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<tbody>
<tr>
<td>OCTOBER 11 - 12</td>
</tr>
<tr>
<td>VHA Annual Policy Conference</td>
</tr>
<tr>
<td>Beyond Survival: Redesigning Healthcare for a Sustainable Future</td>
</tr>
<tr>
<td>Hilton on the Park</td>
</tr>
<tr>
<td>Melbourne VIC AUSTRALIA</td>
</tr>
<tr>
<td>OCTOBER 14 - 17</td>
</tr>
<tr>
<td>Australasian Flow Cytometry Group Meeting</td>
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<tr>
<td>Melbourne VIC AUSTRALIA</td>
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<tr>
<td>OCTOBER 20 - 21</td>
</tr>
<tr>
<td>AIMS NSW/ACTBranch Scientific Meeting</td>
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<tr>
<td>Crowne Plaza Hotel</td>
</tr>
<tr>
<td>Canberra ACT AUSTRALIA</td>
</tr>
<tr>
<td><a href="http://www.trybooking.com/BMIC">www.trybooking.com/BMIC</a></td>
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<tr>
<td>OCTOBER 27</td>
</tr>
<tr>
<td>ASTH Scientific Workshop 2012</td>
</tr>
<tr>
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<td>Melbourne VIC AUSTRALIA</td>
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<tr>
<td>OCTOBER 29 - NOVEMBER 2</td>
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<tr>
<td>ABSANZ Conference</td>
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<tr>
<td>Sofitel Brisbane</td>
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<tr>
<td>Brisbane QLD AUSTRALIA</td>
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<tr>
<td><a href="http://www.absanz.org.au">http://www.absanz.org.au</a></td>
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<tr>
<td>OCTOBER 28 - 31</td>
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<tr>
<td>HAA Meeting</td>
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<tr>
<td>Melbourne VIC AUSTRALIA</td>
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<tr>
<td>NOVEMBER 2 - 4</td>
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<tr>
<td>AIMS NSW North Coast Annual Conference</td>
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<tr>
<td>Darlington Beach Resort</td>
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<tr>
<td>Arrawarra NSW AUSTRALIA</td>
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<tr>
<td><a href="mailto:neil.horton@hnehealth.nsw.gov.au">neil.horton@hnehealth.nsw.gov.au</a></td>
</tr>
<tr>
<td>NOVEMBER 15 - 18</td>
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<tr>
<td>AACB Annual Scientific Meeting</td>
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<td>NOVEMBER 15 - 18</td>
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<tr>
<td>IFCC General Conference</td>
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<td>Kuala Lumpur MALAYSIA</td>
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<tr>
<td>NOVEMBER 25 - 28</td>
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<tr>
<td>Australian Health and Medical Research Congress</td>
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<tr>
<td>Adelaide Convention Centre</td>
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<tr>
<td>Adelaide SA AUSTRALIA</td>
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<tr>
<td><a href="http://www.ahmrcongress.org.au">www.ahmrcongress.org.au</a></td>
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<tbody>
<tr>
<td>NOVEMBER 29 - 30</td>
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<tr>
<td>3rd Conference on Leadership and Practice Development in Health: Quality and Safety through Workplace Learning, Technology and Simulation in Health</td>
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<td>Hotel Grand Chancellor</td>
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<tr>
<td>Hobert TAS AUSTRALIA</td>
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<tr>
<td>DECEMBER 4 - 7</td>
</tr>
<tr>
<td>International Conference on Tropical &amp; Infectious Diseases. Universiti Kuala Lumpur Royal College of Medicine Perek</td>
</tr>
<tr>
<td>Ipoh Perak MALAYSIA</td>
</tr>
<tr>
<td><a href="http://www.perakmed.edu.my">http://www.perakmed.edu.my</a></td>
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<tr>
<td>DECEMBER 8 - 11</td>
</tr>
<tr>
<td>American Society of Hamatology Annual Meeting</td>
</tr>
<tr>
<td>Atlanta GEORGIA USA</td>
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<tr>
<td><a href="http://www.hematology.org/">http://www.hematology.org/</a></td>
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<tr>
<td>MAY 19 - 23</td>
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<tr>
<td>Euromedlab</td>
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<td>Milano Convention Centre</td>
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<tr>
<td><a href="http://www.milan2013.org/">http://www.milan2013.org/</a></td>
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<tr>
<td>AUGUST 22</td>
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<tr>
<td>15th International Congress of Immunology</td>
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<tr>
<td>Rome ITALY</td>
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<tr>
<td>AUGUST 25 - 28</td>
</tr>
<tr>
<td>International Council on Alcohol Drugs and Traffic Safety Conference</td>
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<tr>
<td>Brisbane Convention and Exhibition Centre</td>
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<tr>
<td>Brisbane QLD AUSTRALIA</td>
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<tr>
<td>OCTOBER 6 - 9</td>
</tr>
<tr>
<td>Asia-Pacific Federation for Clinical Biochemistry and Laboratory Medicine Congress</td>
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<tr>
<td>Bali Nusa Due Convention Centre</td>
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<tr>
<td>Bali INDONESIA</td>
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<tr>
<td>OCTOBER 20 - 23</td>
</tr>
<tr>
<td>HAA Meeting</td>
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<tr>
<td>Gold Coast QLD AUSTRALIA</td>
</tr>
</tbody>
</table>
The following instructions are based on the “Uniform Requirements for Manuscripts Submitted to Biomedical Journals”, also known as the Declaration of Vancouver, and on the Australian Government Style manual: for authors, editors and printers, 6th edition, 2002. URLs were correct on September 29th, 2008.

Manuscripts that do not fully comply with the following ‘Instructions to Authors’ may be returned for revision before they are considered for publication.

The Australian Journal of Medical Science (AJMS) will consider for publication any paper relevant to the field of Medical Science. Disciplines include blood banking, clinical biochemistry, haematology, histopathology, immunology, microbiology and molecular biology. Areas of general interest to medical laboratory scientists, including toxicology, epidemiology, public and community health, and professional and management issues will also be considered.

Papers published in the AJMS are in the form of:

- Review Articles
- Original Articles
- Brief Communications
- Technical Notes
- Case Studies
- Letters to the Editor
- Book Reviews

Articles submitted for publication are understood to be offered only to the AJMS and those accepted become the property of the AJMS.

All individuals listed as authors must have made a substantial contribution to the conception and design of the study, the acquisition of data or the analysis and interpretation of data; the drafting of the article or revising it critically for important intellectual content; and final approval of the version to be published. The corresponding author must take responsibility for obtaining permission from all the authors for the submission of any version of the manuscript and for any changes in authorship.

When the manuscript is submitted the authors must disclose any potential conflict of interest and/or commercial support.

Requirements & preparation of manuscripts

General

Articles should be submitted in electronic format to ajms@aims.org.au. If an article is too large to be submitted by email, it should be submitted on a CD.

Number pages consecutively commencing with the title page.

Arrange the article in the following sequence:

- Title page
- Abstract and key words
- Main Text
- Acknowledgements
- References
- Tables - each table, complete with title and footnotes, on a separate page
- Legends for illustrations.

Authors should ensure that their manuscript communicates their ideas and concepts simply and clearly so that the article is easily read and understood. Authors are strongly recommended to refer to the recommendations on reporting standards as outlined in the statements and checklists of the CONSORT group (see: http://www.consort-statement.org/) and similar groups such as STARD (see: http://www.stard-statement.org/). The principles outlined in these standards may be used as general guidelines and not just as applied to clinical trials and diagnostic studies.

Title page

The title of the article should not exceed three lines (40 characters per line), including punctuation and spacing. All authors must be identified on the title page (e.g., William Smith, Susan Yeo, ...”). Where applicable, the title page should also include the name of the institution with which each author is affiliated and to which the work should be attributed. In the case of multiple authors, the name, postal address, email address, telephone and facsimile number of the author responsible for correspondence relating to the manuscript should be indicated.

Abstract & keywords

The abstract should be approximately 150 words and should make sense when read alone or in conjunction with the article. The abstract should be a concise overview that describes the important details of the article including the purpose of the study/investigation, basic procedures (study subjects/experimental animals/observational and analytic methods) and the results and principal conclusions. New and important aspects of the work and its implications may also be included. References should not be included.

Three to ten keywords may be listed. Authors are advised to comply with the terms from the Medical Subject Headings (MeSH) list from Index Medicus (see http://www.nlm.nih.gov/mesh/). Keywords should be given below the Abstract.

Text

The style of writing should conform to acceptable English usage. Do not use slang, medical jargon or
unnecessary abbreviations. Accepted spelling is the first choice given in the latest edition of the Macquarie Dictionary.

Wherever possible observational or experimental articles should be divided into sections headed:
- Introduction
- Materials and methods
- Results
- Discussion
- References

For other types of articles such as commentaries, reports and reviews, use an appropriate format or consult the Editors for guidance.

**Introduction**

Clearly state the purpose of the article leading the reader from the known to the unknown. Summarise the rationale for the study and state the question to be answered as appropriate. Give only strictly pertinent references, and do not review the subject extensively.

**Materials & methods**

Present the materials and methods in a logical sequence. Describe the selection of the observational or experimental subjects (patients or experimental animals, including controls) clearly. Notification of ethics approval must be given where relevant. Identify the methods, apparatus and procedures in sufficient detail to allow other workers to reproduce the results. Give references to established methods, including statistical methods. Adequately describe new or substantially modified methods. Identify precisely all drugs and chemicals used, including generic name(s), dosage(s), and route(s) of administration. Do not identify patients or hospitals without consent.

**Results**

Present the results in the same sequence as given in the Materials and methods; use tables and illustrations where these will help the reader understand the work being presented. Do not repeat in the text all the data in the tables or illustrations.

**Discussion**

Indicate the new and important aspects of the study and emphasise the conclusions that follow. Do not repeat in detail data given in the Results section and do not add new data. Include in the Discussion the implications of the findings and their limitations and compare the observations to other relevant studies. Recommendations may be included if appropriate. Link the conclusions with the goals of the study and answer the experimental question stated in the Introduction. However, avoid unqualified statements and conclusions not completely supported by your data. Avoid claiming priority and alluding to work that has not been completed. State new hypotheses when warranted, but clearly label them as such.

**Acknowledgements**

Acknowledge individuals who have made substantial contributions to the study including technical work and financial support. Authors are responsible for obtaining consent from all the individuals acknowledged by name as inclusion may be interpreted as an endorsement of the article's contents.

**References**

The AJMS uses a modified Harvard System (author-date system).

Throughout the body of the manuscript cite the author/s name and the publication year in parentheses as in the following examples:

(i) Research in this area (Jones 1999) …
(ii) It has been successfully demonstrated that (Smith and Brown 1981; Auteur 1995; Scienziato et al 2007).

Where there are three or more authors, acknowledge only the first author, e.g., (Smith et al 2007). For two authors the following style should be used: (Smith and Brown 2007).

The reference list should be in the format described below. Journal titles should be abbreviated in Index Medicus format (see: ftp://nlmpubs.nlm.nih.gov/online/journals/ljweb.pdf) using standard abbreviations from the ISSN List of Title Word Abbreviations (see: http://www.isssn.org/en/node/344) All authors should be given in the reference list.

Do not use abstracts as references. “Unpublished observations” and “personal communications” may not be used as references, although references to written, not verbal, communications may be cited (in parentheses) in the text. Include in the references manuscripts accepted but not yet published, designate the journal followed by “in press” (in parentheses). Information from manuscripts submitted but not yet accepted should be cited in the text as “unpublished observations” (in parentheses).

Examples of the correct form for references are given below:

i) Journal Reference:

ii) Personal Author(s) of a book:

iii) Editor, Compiler, Chairman as Author:

iv) Chapter in Book:
Tables
Number tables consecutively with Arabic numerals and supply a brief title for each. Give each column a short or abbreviated heading. Place explanatory matter in footnotes, not in headings. Explain in footnotes all non-standard abbreviations used in each table.

For footnotes, use the following symbols in this sequence:
* † ‡ § ¶ ** ††

In preparing tables, consideration should be given to the page width of the Australian Journal of Medical Science. All tables should be prepared for publication vertically. In the text, cite each table in consecutive order, and mark in the margin of the text its approximate location.

If data from another published or unpublished source is used, written permission must be obtained and a copy must accompany the manuscript.

Illustrations
Colour illustrations may be submitted on a CD. Images should be scanned at a minimum of 300 dpi.

When plotting points, the following symbols are preferred:

\[ \bullet \uparrow \downarrow \square \]

In most instances, figures will be reduced to one column in width. All letters and numbers should be drawn to be at least 1.5 mm high after reduction, symbols at least 1.0 mm. Titles for illustrations belong in the legends for illustrations and not on the illustrations themselves.

Photomicrographs must have internal scale markers and the magnification must be stated. Symbols, arrows, or letters used in the photomicrographs should contrast with the background.

Cite each figure in the text in consecutive order, e.g., “Figure 1 illustrates …” or “… as shown (fig. 2)”. If a figure has been published, acknowledge the original source and submit with the manuscript written permission from the copyright holder to reproduce the material. Permission is required, regardless of authorship or publisher, except for documents in the public domain.

Legends for illustrations
When symbols, arrows, numbers, or letters are used to identify parts of illustrations, identify and explain each one in the legends. The figure legend must contain a boldface (a) name (“Figure” + arabic figure number) and (b) substantive title.

Abbreviations
Use only standard abbreviations (see list of commonly used abbreviations, below).

Avoid abbreviations in the title. The full term for which an abbreviation stands must precede its first use in the text unless it is a standard abbreviation for a unit of measurement.

Report measurements in the units in which the measurements were made. In most countries the International System of Units (SI) is standard.

Commonly used abbreviations

<table>
<thead>
<tr>
<th>Abbreviation or Symbol</th>
<th>Standard Units of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>g</td>
<td>gram</td>
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<tr>
<td>g</td>
<td>gravity</td>
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Additional information
The following are useful sources of information. The first two publications are used by the AJMS as standard references.


Laboratory services play a critical role in healthcare. To meet new demands labs must respond to change, use automation and manage device integration. The pay-off? Pathologists and laboratory staff unburdened by menial tasks - freeing them to support clinicians with expert insights and better service.

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Haemolytic Uraemic Syndrome in an eight-year-old child

ORIGINAL ARTICLE
Serum uric acid and albumin levels and estimated glomerular filtration rate: oxidative stress considerations

ORIGINAL ARTICLE
Efficient haematology testing through hardware and software automation