NATIONAL BLOOD AUTHORITY
AUSTRALIA

USE OF SMALL VOLUME TUBES TO REDUCE BLOOD LOSS

CASE STUDY:

Flinders Medical Centre

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1. Patient Blood Management

Patient Blood Management (PBM) aims to improve patient outcomes through the application of evidence based medical and surgical strategies that optimise and conserve the patient's own blood. The PBM approach requires identification of critical opportunities in the continuum of patient care where communication and coordination between different disciplines can reduce the likelihood that a patient will require an allogeneic blood transfusion. Strategies aimed at minimisation of blood loss, for example using small volume tubes (SVTs) for the collection of blood samples, should be considered as part of routine blood conservation efforts.[1]

The three pillars of PBM

The use of SVTs aims to minimise phlebotomy volume as a component of the second pillar of PBM guidelines (minimisation of blood loss).[2] In Module 4: Critical Care, [3] the role of strategies to reduce iatrogenic blood loss was highlighted as an area for further research as there was insufficient evidence to generate recommendations at the time of publication.

The Patient Blood Management Guidelines: Module 6: Paediatric and Neonates[1] also highlight this as a potential strategy where safe and feasible (below).

EXPERT OPINION POINT – strategies for minimisation of blood loss

EOP27

Strategies to safely minimise phlebotomy losses should be used for all neonatal and paediatric patients. Such strategies may include (where safe and feasible):

- use of 'as-needed' rather than routine sampling
- meticulous avoidance of blood overdraw
- return of void volumes to sampling lines
- use of closed inline sampling devices
- judicious use and 'on-time' removal of sampling lines
- optimal sampling technique and sample handling to minimise rejection of samples by laboratory
- laboratory equipment that uses the smallest possible sample volumes
- use of non-invasive techniques and point-of-care devices
- audit compliance and cumulative phlebotomy losses in selected groups of patients at regular intervals.

Figure 1 - Expert opinion point from Patient Blood Management Guidelines Module 6: Paediatric and Neonatal

The PBM Guideline Companions

The PBM Guidelines Companion #17 is titled 'Reduce iatrogenic blood loss'. It defines iatrogenic anaemia as anaemia that results from blood loss due to repeated venepunctures for the purposes of obtaining specimens for laboratory testing. Strategies to reduce iatrogenic blood loss include altering of test ordering behaviour (limiting the number of tests ordered), micro-sampling, reinfusion of blood drawn from indwelling devices and point of care microanalysis.

Key messages of the companion are:

- Diagnostic testing is an important cause of blood loss in critically ill patients.[4]
- The use of micro-sampling has been shown to significantly reduce the volume of blood loss
- In one study micro-sampling has been associated with a significant reduction in blood transfusion.
- The introduction of point-of-care testing could further reduce the volume of samples drawn. [4]

Companion #17 acknowledges the need for strategic planning, communication and implementation with relevant stakeholders such as medical staff, laboratory scientists and nursing staff to implement strategies to reduce iatrogenic blood loss. Individual laboratory validation of SVT's is highly recommended.

Blood conservation strategies

With regard to blood collection practices, a number of blood conservation strategies exist. These include:

- Reducing the frequency of blood sampling
- Minimising the volume of blood collected
- Maximising the number of tests done from a single tube
- Use of blood conservation devices that reduce the amount of blood that needs to be discarded when clearing the locked line from heparin or saline.

These strategies form an important part of overall Patient Blood Management based on the three pillars of optimisation of blood volume and red cell mass, minimisation of blood loss, and optimisation of the patient's tolerance of anaemia.

2. Background – the Flinders Medical Centre experience

Rationale

Blood loss due to diagnostic blood testing in ICU patients contributes to the frequency and severity of anaemia [5] [6] [7]. Hospital acquired iatrogenic anaemia is common in long stay ICU patients. [8] Adverse consequences of anaemia include fatigue with associated symptoms of breathlessness, decreased exercise tolerance, cognitive impairment and general lower quality of life.

Small increases (as little as 3.5 mL per day) in the average volume of blood drawn double the odds of being transfused after day 21. [9] For every 100 mL of blood withdrawn, there is a decrease of 7 g/L in haemoglobin.[10] A reduction in iatrogenic blood loss reduces the risk of anaemia and potentially the

need for allogeneic blood transfusion. Blood transfusion is an independent risk factor for mortality, morbidity and length of stay in hospital. [11]

Setting

The clinical practice described in this document primarily occurred within the intensive care unit (ICU) at Flinders Medical Centre (FMC) Adelaide – South Australia (SA). FMC is a major hospital with approximately 580 beds, located 12 km south of the Adelaide CBD. The ICU treats surgical, obstetric and medical patients. It is a 32 bed unit with approximately 185 full time equivalent nursing staff. This equates to approximately 275 nursing staff. There are 13 consultants and 30 junior doctors and trainee medical officers.

Scope

This case study focuses on the implementation of SVTs within the ICU at FMC. The case study does not include populations other than adult long stay ICU patients, and the use of other strategies that may reduce the volume of iatrogenic blood loss, anaemia and incidence of transfusion, such as:

- paediatric blood collection tubes
- blood conservation devices (including replacement or avoidance of discard or void volumes in sampling lines)
- use of non-invasive or point-of-care (POC) devices,
- different central line/central venous access devices (CVAD) with the potential to reinfuse discard volumes

SVTs can be used for most routine laboratory tests including full blood counts, biochemistry and routine coagulation tests, with the exception of monitoring activated partial thromboplastin time (APTT) in patients treated with unfractionated heparin. [12, 13]

3. Methodology

In 2011, FMC and SA Pathology conducted a study to determine if the implementation of routine use of small volume tubes for blood collection in longstay ICU patients reduces iatrogenic blood loss, and whether this translates into reduced frequency and severity of anaemia, reduced transfusions and the impact of the process on staff and laboratory functioning. At the onset of the project it was clear that the change to SVTs had to be sustainable. To achieve this, the tubes had to be compatible with the existing laboratory analysers, able to be fully automated and cost neutral.

In July 2011 SVTs replaced standard volume tubes.

	Standard tube	**SVTs**
EDTA for FBC	4 mL	2 mL
Gel serum clot activator	9 mL	5 mL
Sodium citrate	3.5 mL	2 mL
Lithium Heparin + gel	9 mL	2.5 mL
EDTA for transfusion	9 mL	6 mL

A sub-group of patients known to require longer length of stay in ICU was identified for 2 periods: 1 February 2010 - 30 June 2011 ('before' introduction of SVTs) and 1 August 2011 - 30 June 2012 ('after' introduction of SVTs) with a cross-over familiarisation period of 1 month (July 2011). 266 and 206 patients were identified 'before' and 'after' the introduction of SVTs respectively. Patients' characteristics were comparable for both study periods.

Data linkage was used to combine hospital and laboratory databases. The following data was extracted for the study periods: patient demographics, admission details, haemoglobin levels, number of diagnostic blood tests, and number of red blood cell units transfused. The volume of blood loss due to diagnostic sampling was calculated by assuming the standard volume of each tube type and that the minimum number of blood tubes was collected to perform the reported tests. The impact on laboratory functioning was determined using Lab IT systems.

Laboratory practice

Volumes required by the analysers at FMC were not impacted by the introduction of SVTs (required volume is less than that contained in the SVT). The impact of the SVTs on the laboratory function was monitored. Meeting occurred weekly with the Laboratory Manager to review and discuss progress and issues. Statistics on rejected specimens (e.g. due to short volume/insufficient volume for add on tests and/or repeat testing) were reviewed.

In order to implement the introduction of the SVTs:

- Validation of SVTs was required
- Compatible labelling was to be ensured
- Sufficiency of samples needed to be monitored
- Compatibility of SVTs with current laboratory analysers were confirmed
- Full automation of analysing SVTs, no uncapping was required
- SVT's had to be cost neutral
- Stock level adequacy was needed
- No potential for confusion in handling samples was required

4. Implementation

The study was implemented within the ICU at FMC as the long-stay patients in ICU were the most at risk of iatrogenic hospital acquired anaemia. Implementation required support from the transfusion Committee, ICU consultants, a transfusion nurse, ICU nurses, laboratory staff and the pathology service.

Pre-implementation planning

- Analysis of amount of blood collection tubes used per month to estimate the quantity of SVTs required
- Permission to request holding stock changes
- Development of educational resources and a process to review these with staff
- Development of a review process of the impact on laboratory functioning
- Approval from clinical area director

Pathology service and supply of SVTs

An important first step was to engage the pathology service to ensure they could provide SVTs, and to have the correct analysers in the hospital to accommodate those tubes. At FMC, SA Pathology took on the role of sourcing the SVTs from a supplier. The amount required was calculated. The impact on laboratory workload, sample handling, labelling, centrifugation and sufficiency of samples was monitored.

Clinical practice change in ICU

Importantly, clinicians need to be engaged to integrate the use of SVTs into their everyday practice. Most staff at FMC was of the view that using SVTs was something that should be done; however senior clinicians support is needed to promote the process. Clinical staff were made aware of the change to using SVTs and that the results are reliable. A poster at each bay of the new tube sizes, the use of vacutainers to ensure correct fill of the test tubes, international order of draw (**Attachment A**) and the maximum discard volume served as reminders.

Blood collection in ICU

It took approximately six months of planning. An implementation date was set and all standard volume tubes were removed from every bay, trolley and storage area in ICU to ensure that only the SVTs were available. Ongoing education was provided to all staff. Staff was encouraged to report any issues with the use of SVTs.

In order to implement the introduction of the SVTs:

- All standard tubes were replaced at a specific time and date agreed by the unit
- All staff were provided educational resources and notified of the timeframe of change
- Stock request change was completed and barcode changes undertaken (by stores)
- Educational material was displayed at all collection stock areas and courier drop off points
- Adequate stocks of interlink transfer devices (tubes should not be filled through cap removal)
- Order of draw (vacutainer use) was maintained to minimise cross contamination tube medium/additive

5. Education to embed SVTs as standard care

Implementation of SVTs at FMC required engagement across all clinical groups with targeted information sessions to a wide range of staff, both formally and informally, utilising multiple avenues available to increase awareness and education. Tools and feedback opportunities were developed to support clinical staff. These included:

- Correct order of draw poster
- Correct vacutainer technique in specimen collection ?poster
- Compulsory ‘fill to line’ for all SVTs ?poster
- Acknowledgement that overfilled tubes cannot be processed
- Feedback opportunities during implementation
- Data on adverse collections, rejected sample, overfilled/underfilled tubes
- Minimising excess line discard in PICC, CVC, Infusaport (discard volumes based on line volume + 3ml/maximum 5ml

6. Outcomes

Routine use of SVTs in the ICU significantly reduced the volume of blood loss due to diagnostic testing without adversely affecting the laboratory workflow and may have reduced the incidence of transfusion and associated potential for adverse effects.

Median volume of blood lost due to diagnostic testing was significantly lower in the 'after' period compared to 'before' (396 mL versus 605 mL, $p<0.001$). Median red blood cell units transfused in ICU per patient were lower in the 'after' period compared to 'before' (2 units versus 3 units, $p=0.01$). The 'after' group had a reduction in red blood cell transfusions, minimising exposure to the associated risks and costs.

Pre-implementation modelling and subsequent data analysis showed an overall reduction of approximately 40% of blood collected for pathology testing using the SVTs.

Introduction of SVTs did not impact adversely on laboratory functioning. There was:

- No change in workload or workflow
- No changes in standard operating procedures in haematology, biochemistry or routine coagulation test (It is not indicated for use in APTT monitoring for patients treated with unfractionated heparin)
- No confusion in sample handling as SVTs were handled the same as the standard tubes
- No significant number of inadequate volume for 'add-on' tests was detected
- No change to speed or specifications for centrifugation as SVTs were same height as the standard tubes

There was a slight increase in tube labelling which obscured the visible column of blood (required to inspect the appropriateness of fill). A new statewide computer system being introduced in South Australia in 2017/2018 will enable current labelling issues to be resolved with a standard patient label able to be produced to specification of size, identifiers and barcodes.

Using vacuum devices to correctly fill tubes, maintaining correct order of draw, and accurately labelling specimens using recognised patient identity processes were learning curves during implementation.

There was an issue during weekends and out of hours, when standard tubes were being taken and used from other areas. It is important to keep on top of feedback from the laboratory on over and under fills and any abnormal test results, engage with staff in the unit where to access the SVTs, and gather feedback on how tube colour and size affects their everyday workflow. Getting feedback on these issues as soon as possible and having a contingency plan if you do run out of SVTs is essential. All collection staff across FMC now uses the SVTs and they are also used in the day treatment units. There are plans to expand throughout the whole of FMC.

7. Benefits

Improved patient outcomes were the core objective of implementing SVTs. Patient Blood Management improves patient outcomes by improving the patient's medical and surgical management in ways that boost and conserve the patient's own blood. As a consequence of better management, patients usually require fewer transfusions of donated blood components thus avoiding transfusion-associated complications. Using SVTs demonstrated that patients lost less blood and potentially fewer patients may require transfusions of donated blood components thus avoiding transfusion-associated complications.

The implementation of SVTs at FMC has led to a variety of successes including:

- Increased awareness of Patient Blood Management
- Increased awareness that iatrogenic blood loss can be reduced without inconvenience to clinicians and the laboratory
- Increased awareness of the benefits to patients
- Expanding the use of SVTs into other areas of FMC
- Reduction in discard volume
- Improved patient outcomes
    - Reduced blood loss due to sampling
    - Reduced risk of iatrogenic anaemia
    - Reduced risk of red blood cell transfusion
- Decreased cost (associated with red blood cell transfusion)
- A trend toward reduction in length of stay in ICU
- No additional costs and reliable and accurate results

8. Barriers for implementing SVTs

In general, hurdles for implementing SVTs (barriers) include the following:

- Knowledge of PBM guidelines
- Reluctance to change from current practice
- Economic and logistical issues surrounding implementing change in practice
- Translating evidence into practice – potentially one of the biggest hurdles as this requires dedicated drivers to implement evidenced based guidelines
- Minor labelling issues, where labels were longer than the tubes making visuals of the blood within the tube prior to inserting in the testing equipment difficult
- Over and under filling of tubes (leading to a rejection and repeat of the specimens)
- Time constraints for busy staff delivering complex care
- Competing priorities & changes in other aspects of care and within the organisation.
- Local laboratory validation of all tests that SVTs will be used for

9. Discussion

Hospital acquired iatrogenic anaemia (IA) is a well-described entity in especially long stay patients in ICU. It is imperative to endeavour to minimize iatrogenic blood loss contributing to anaemia and potentially leading to increased blood transfusion requirements and associated risks and cost. It has been shown that blood loss due to blood sampling contributes significantly to IA. A simple, but highly effective way of reducing blood loss is to withdraw less blood with every episode of sampling. This study showed that it is possible to use SVTs without adversely affecting the function of the automated laboratory and still have reliable and accurate results. Local laboratory validation for all tests done using SVTs is essential. The small problem of overfilling of the coagulation tubes was easily overcome by education regarding vacutainer use. ICU and laboratory staff reported no major problems in implementing SVTs and saw it as an important strategy.

Patient characteristics of age, gender and APACHE II scores were comparable in the 'before' and 'after' SVTs study groups. There was a significant reduction in calculated blood loss due to sampling for laboratory testing in the 'before' and 'after' introduction of SVTs periods. The reduction in blood loss due to sampling may have contributed to the observed statistically significant reduction in red cell transfusions. The decrease in red cell volume transfused is clinically significant as it was a reduction of 1 unit of red cells per patient per ICU stay.

Limitations of the study include calculation of the blood loss (with the need to make assumptions about tube fill and number), the 'before' and 'after' study design with differences in clinical practice (changes in clinical transfusion practice, discard volume), and lack of multivariate analysis. There may be important differences between the patient groups in terms of comorbidities such as the ability of bone marrow to recover from IA (e.g. renal failure) and the threshold at which transfusion is needed (e.g. acute coronary syndromes) that we have not correct for. Despite this, implementation of SVTs at least minimises unnecessary blood loss due to sampling that in at least some patients will translate into reduced risk of anaemia and exposure to transfusion (and its associated risks and costs) and possibly reduced length of stay. There were no implementation difficulties encountered and no additional costs to balance this against.

10. Recommendation

Institutions with patients that require frequent blood sampling should consider the use of small volume blood collecting tubes to reduce iatrogenic induced hospital acquired anaemia if compatible with existing laboratory analysers and subject to local validation.

Attachment A – SA Pathology Order of Draw Quick Guide

ORDER OF DRAW–QUICK GUIDE
Hospital Standard and Short Draw

SA PATHOLOGY

Minimise collection volumes where clinically indicated. Consider using microtainer tubes.
Paediatric volumes should be calculated by patient weight.

Order of Draw	Contents	Test
	Bactec Aerobic (blue) Anaerobic (purple)	Blood Cultures (paired bottles)
BLUE 2mL 3.5mL	Sodium Citrate	***Critical – Always fill to minimum draw line*** Coag Studies, INR, APTT, PT, Fibrinogen, D-Dimer Clotting Factors, Antithrombin III, Protein C, Protein S
RED/WHITE 5mL 8mL	GEL (Serum - Fast Clotting)	PSA, TFT, Tumour Markers, Iron Studies, B12, Drugs, Hormone Levels, EPG, CRP, Viscosity, Troponin, Vitamin D, Serology, Auto antibody tests, Infectious Diseases Serology
GREEN/YELLOW 5mL 8mL	Heparin+GEL	ECU, LFT, CK, LD, Ca, Phos, Creatinine, Lipase, Magnesium, Uric Acid, Lipids, Alcohol, TFT, Osmolality, Ethanol (non forensic), Troponin
GREEN/BLACK 5mL 8mL	Heparin	Cholinesterase, Lymphocyte Surface Markers, Cytogenetics, Clozapine, Perhexiline, HLA B27, CD4, CD8, FISH/Karyotype/Chromosomes, Thiamine (protect from light), T Cell subsets
PINK 6mL	EDTA	**Transfusion**: G&S, G&M, Direct Anti-globulin(Coombs), Cord Blood, Transfusion Reaction, Antibody Screen
PURPLE 2mL 4mL 9mL	EDTA	**4ml**: CBE, ESR, Haemoglobin, HbA1c, Haemoglobinopathy/Thalassaemia Screen, Red Cell Folate, Lead, Mercury, Haemochromatosis, Cyclosporin, Tacrolimus, Renin, Factor V Leiden **9ml**: Molecular Genetic Tests
PURPLE/YELLOW 8mL	EDTA+GEL	Homocysteine, Ammonia, PTH Blood borne Viral PCR tests: RNA, DNA, Viral Load, Genotype
YELLOW 9mL	ACD	Tissue Typing, Platelet 'Clumping'
GREY 2mL 4mL	Fluoride EDTA	Glucose, Alcohol, Lactate, Ketones

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