Continuous Renal Replacement Therapy: Current Practice in Australian and New Zealand Intensive Care Units

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Abstract

Background: The publication of large multicentre studies devoted to Continuous Renal Replacement Therapies (CRRT) in critically ill patients may influence the bedside prescription and practical application of the treatment. Despite this, many aspects of this therapy may not be informed by evidence, but remain a product of clinician preference. Little is known about the current CRRT practice in Australian and New Zealand (ANZ) ICUs and it is not known if the evidence from recent studies has been integrated into practice.

Design and Setting: A prospective on-line survey of CRRT practice was sent to ICU clinicians (medical and nursing) via three different national databases in ANZ ICUs during December 2013 to March 2014.

Results: There were 194 respondents from 106 ICUs: 49 ICUs (47%) were in tertiary metropolitan hospitals. One hundred and two respondents (52%) reported CVVHDF as the most common CRRT technique with the combination of pre and post-dilution of replacement solutions. There is variability in the prescription of dosing for CRRT with respondents indicating the therapy based on litres per hour (53%) or a weight adjusted treatment in mls/kg/hr (47%).

For all modes of CRRT, the common blood flow rates applied were 100-150 and 150-200 ml/min; with few respondents reporting flow rates < 150 or > 300 ml/min. Unfractionated heparin was the most common (83%) anticoagulant followed by regional citrate. Femoral vascular access was preferred and typically a 20cm length device inserted with Bard Niagara® and Arrow® access catheters most frequently used. The Baxter/Gambro

Prismaflex™ was the dominant machine platform with 71% of respondents indicating its use in their ICUs.

Conclusions: These results provide insight into existing clinical management of CRRT. Considerable variation still exists in the practical prescription of CRRT in ANZ ICUs.

Key words: Continuous Renal Replacement Therapy, filter life, dose, continuous haemofiltration, acute kidney injury, critical care

Introduction

Acute kidney injury is a significant and recognized complication of critical illness that affects 2-7% [1-3] of hospitalized patients and up to 34% of critically ill patients. [4-6] AKI can result in severe derangements in fluid, electrolyte and acid-base balance requiring the intervention of supportive strategies. The use of Renal Replacement Therapy (RRT) forms a key component in the treatment for severe AKI and its use is required in up to 5-6% of all critically ill patients in intensive care units (ICUs).[7]

The technical application of RRT has been highlighted in recent years with several large multicentre randomized controlled trials[8-9] investigating 'technique' and 'dose' and association with mortality as the primary outcome. In the 'RENAL' study[8] 1464 patients receiving Continuous Renal Replacement Therapy (CRRT), specifically continuous veno-venous haemodiafiltration (CVVHDF), were explored at different dose intensities and results indicated no difference in 90 day mortality. Similarly, in the 'ATN' study[9] 1124 patients receiving Intermittent Haemodialysis (IHD), Slow Low Efficiency Daily Dialysis (SLEDD) and CVVHDF at different dose intensities also indicated no difference in 60 day mortality. Technical information pertaining to the application of RRT for the treatment of AKI was illustrated in several pre study practice surveys.[10-11] Technical aspects such as modality, dose, dose prescription, replacement/dialysate fluid type, blood flow rate, pre/post dilution for replacement fluid and machine types were explored in detail. More recently, two international groups have investigated the current management, practices and practitioner beliefs following the dissemination of results from both the RENAL and ATN trials.[12-13] Of particular importance is whether CRRT practices have changed in response to these studies. These later surveys have however concentrated on dose, modality and timing of RRT with

limited information regarding practical or technical aspects associated with the application of therapy.

To date there has been no data published describing alteration in practice for Australian and New Zealand intensive care clinicians following outcomes of the RENAL or ATN studies. In addition to practice changes following the results of these studies, there have been significant enhancements to capacity and flexibility in functionality of CRRT machines since the pre RENAL practice survey conducted in 2004. This improvement in machine design and functionality may have prompted changes to prescribing practices of CRRT in many ANZ ICUs.

The aim of this survey was to establish the current practical prescription of CRRT in ICUs caring for adult and paediatric patients in ANZ.

Methods

Survey method

A descriptive online survey was distributed from December 2013 to March 2014 requesting information from clinicians about their current practical application of CRRT. A sample of ICU medical and nursing staff was accessed via three separate databases. The Australian and New Zealand Intensive Care Society Clinical Trials Group (ANZICS CTG), the Intensive Care Coordination and Monitoring Unit (ICCMU) ICU Connect list server and the Australian College of Critical Care Nurses (ACCCN) databases were used to seek participants for the survey. Ethics approval was granted by the Austin Health Human Research Ethics Committee (project No. 04918) prior to study commencement. Consent to participate was implied by submission or return of the questionnaire.

Survey Design

The survey was devised from the pre 'RENAL study' practice questionnaire conducted in 34 ANZ ICU's in 2004 and published in 2008.[10] The tool used for this survey was a modification of the eleven-point questionnaire and consisted of 20 questions. (A copy of the survey is available online as supplementary material). Demographic questions included the practitioners' state or territory, study site (hospital), professional role (Intensivist, Nurse Unit Manager etc) and type of intensive care (adult, paediatric). In addition respondents were asked to identify the number of beds and type of ICU (metropolitan tertiary, private etc) as well as the number of patients they treated with CRRT each year. Twelve questions focused on the prescription of CRRT, including specification of the modalities of CRRT used (haemofiltration, haemodialysis, haemodiafiltration); specification of prescribed blood flow rate; if they prescribed CRRT on the basis of patient weight or alternatively litres per hour and prescribed replacement or combined with dialysate flow rates. The respondents were also asked to identify the preferred anatomical site for vascular access, the catheter type and usual length of catheter, the anticoagulation regimen used and type of machine used for CRRT.

Statistical analysis

Descriptive statistics were used for all demographic and clinical data and for all items in the survey. Data were cleaned and checked for missing values and invalid responses. The prime reporting statistics were expressed as frequencies and percentages. Statistical analyses were performed using Stata version 11 (Statacorp).

Results

Characteristics of the cohort

Survey invitations were emailed to 4115 potential participants via ACCCN (1853), ICCMU (1652) and ANZIC's clinical trials group (600) membership. There is likely duplication between these databases, with an unknown number of people appearing on two, or all three databases so it was not possible to know the precise number of invitees. One hundred and ninety four responses were received with 106 intensive or critical care units from ANZ represented. Overall, the majority of respondents came from New South Wales (26%) and Victoria (27%). Most respondents worked in metropolitan ICUs (73%), with the largest group working in metropolitan level three tertiary institutions (47%) caring for adult patients only (69%) (Table 1). Consultant intensivists represented 19% of the total responses with clinical educators (19%), clinical nurses specialists (24%) and registered nurses (22%) filling the larger part of nursing roles. One third (36%) of respondents worked in units of 6-10 beds with 24% working in ICU's > 20 beds. One quarter (25%) of respondents indicated their ICU treated > 100 patients per year with some form of CRRT.

CRRT Mode and Dose

There was obvious clinical variation in the dose prescription for CRRT. Fifty three percent of respondents indicated the standard treatment dose of CRRT was prescribed in their ICUs in litres per hour, whilst 47% indicated a prescription aimed at a weight based dosing strategy of mls/kg/hr. The most common CRRT technique was Continuous Veno-Venous Haemodiafiltration (CVVHDF), with 54% of respondents indicating they 'always' use this

mode of therapy. In contrast 9% and 2% indicated they 'always' have Continuous Veno-Venous Haemofiltration (CVVH) or Continuous Veno-Venous Haemodialysis (CVVHD) prescribed in their ICUs respectively.

CVVHDF in combination with pre and post fluid replacement (pre and post dilution) was indicated by respondents as 'always' prescribed in 29% of treatments with predilution CVVHDF (13%) and postdilution CVVHDF (12%) the next most used practices. If CVVHDF was prescribed in a standardized dose of litres per hour (L/hr), respondents reported a dose between 1) L/hr for dialysis (D) + 1 L/hr as replacement (R) fluid frequently or always used in 39% of treatments with a dose 2(D) L/hr + 2(R) L/hr in 38% of cases. CVVHDF set at 16-25 mls/kg/hr was the most common weight based regimen with 47% frequently or always prescribing this dose, while > 25mls/kg/hr (39%) was the next most utilized dosing regimen (Table 2).

If CVVH was prescribed in a standardized dose of litres per hour (L/hr), respondents reported a dose between 2-3 L/hr as frequently or always used in 20% of treatments with a dose > 3 L/hr in only 9% of cases. CVVH set at > 25 mls/kg/hr was the most common weight based regimen with 16% frequently or always prescribing this dose (Table2).

Blood flow rate

A blood pump speed (set blood flow rate) of 150-200 mls/min was 'frequently' or 'always' used in 59% of CVVHDF and 60% of CVVH treatments respectively. A prescribed rate of 200-250 mls/min was the next most used with 46% (CVVHDF) and 50% (CVVH) respondents 'frequently' or 'always' using this range (Table 2). Fifty one percent of respondents

suggested the blood flow rate for CRRT was prescribed by unit policy or protocol, with 29% prescribed by medical staff and 20% set by the allocated bedside nurse.

The management of frequent CRRT machine alarms included the manipulation of blood flow rate in an attempt to decrease alarm conditions such as elevated Transmembrane Pressure (TMP), high return or venous pressures with 34% of respondents indicating they 'frequently' alter the pump speed to alleviate alarm conditions in an attempt to continue therapy.

Vascular Access

The right and left femoral vein were favoured as the access site of choice for CRRT (Table 3). The next most common site was the right internal jugular vein with few respondents indicating the use of subclavian veins. Bard Niagara® and Arrow® catheters were the most frequently used access devices with a length of 20 cm preferred for all access sites.

Anticoagulation

Unfractionated heparin was the anticoagulation of choice with 83% of respondents either 'frequently' or 'always' using this medication regimen to extend circuit life in CRRT. Regional techniques were less likely to be utilised with regional heparin and protamine (18%) and regional citrate in combination with CVVHDF (21%) 'frequently' or 'always' used. Eighty percent of respondents indicated they 'occasionally' used a 'no anticoagulation' strategy in place of drug based anticoagulation treatment for CRRT (Figure 1).

Machines

The most commonly used CRRT machine was the Prismaflex (Baxter Gambro, Deerfield, USA) (71%), followed by Aquarius (Nikisso, San Diego, USA) (27%), Prisma (Baxter Gambro, Deerfield, USA) (8%) and Infomed HF440 (Infomed, Geneva, Switzerland) (5%).

Discussion

Summary of major findings

Clinical practice prescriptions for the management of CRRT in ANZ ICUs were assessed in this study with five key findings identified. First, CVVHDF was the mode of CRRT most commonly used, typically using a combination of pre and post filter fluid replacement. Second, approximately half the respondents indicated their practice was to adjust the dose of therapy according to body weight (mls/kg/hr), while half of the respondents used a standardised dose (litres per hour). Third, prescribed blood flow rate was highly variable, although 150-200 mL/min was the most commonly prescribed rate for CVVH and CVVHDF. Fourth, the femoral veins were the sites of choice for vascular access. Finally, unfractionated heparin is the most commonly used anticoagulant used in CRRT.

Contrast with previous studies

The Australian and New Zealand Intensive Care Society (ANZICS) Centre for Outcome and Resource Evaluation assumes that by ANZICS definitions[14] for patient acuity managed, all level 2 and level 3 intensive care units (public and private hospitals) are capable of performing renal replacement therapy in ANZ. If we continue this assumption the cohort of RRT capable ICUs would number 145. Three quarters (n=106, 73%) of these ICUs completed

the survey, suggesting a strong representation of units capable of performing RRT in ANZ. In 2001, Silvester and colleagues reporting on the management and epidemiology of acute renal failure, investigated aspects of RRT practice in 81 Australian ICUs.[15] Technical aspects in this study were limited to vascular access site, anticoagulation and mode of therapy. The only other reported study into local CRRT practices was prior to the RENAL study which investigated 34 participating trial ICUs in ANZ.[10] This study conducted in 2004 investigated the technical and practical application of the therapy and served as the foundation for the current survey.

Internationally, the BEST kidney study[1] investigated world-wide CRRT practice in 54 centres across 23 countries following the introduction of consensus guidelines and recommendations from the Acute Dialysis Quality Initiative (ADQI) in 2002. This multi-national, multicentre study investigated technical aspects of the therapy including modality, dose, dilution method, membrane type and blood flow. The VA/NIH Acute Renal Failure Trial Network (ATN) pre study practice survey[11] reported the findings from 130 practitioners in 27 medical centres in the US. Nine of the 26 questions specifically related to CRRT prescription, including estimation of frequency of use, vascular access (arterial, venous), mode, blood flow rates, type of fluids and dose prescription. Perhaps the largest survey investigating RRT practice involved 560 European critical care nephrology conference participants.[16] The majority of the respondents were nephrologists (52%) with CRRT prescribing physicians accounting for 25% of the responses. The technical aspects surveyed related to dose, modality and anticoagulation with more detailed technical prescription not addressed.

Since the RENAL (2009)[8] and ATN (2009)[9] studies, there has been limited investigation to alteration in practice and prescription of CRRT, despite the publication of the respective findings from these two large, and potentially influential studies. In 2010, the European Society of Intensive Care Medicine (ESICM) investigated the current practices associated with RRT from 272 physicians.[12] Despite a high number of respondents; the survey had limited technical description of technique and prescription, but did provide insight into practices relating to dose, modality and intensivists' beliefs regarding the optimal management of RRT. A survey of 167 ICUs (intensivists) in 2009/10 investigated the management of AKI and RRT in UK.[13] Modality and dose were addressed with little information of specific technical prescription. Our survey with a large representative sample from ANZ ICUs is the largest examination of the technical prescription of CRRT since publication of, and the recommendations from the RENAL and ATN studies.

Mode of therapy

The dominant mode of CRRT in ANZ is CVVHDF with 54% of respondents indicating they always use this mode with CVVH (9%) and CVVHD (2%) less frequently favoured. Prior to the RENAL study, 62% of ICUs (21/34) indicated CVVHDF as their preferred mode.[10] ICUs had previously reported a higher use of CVVH with 35% (12/34 ICU's) compared to our findings.[10] Internationally there remains great variation in practice in relation to modality of choice. The ESICM survey reported only a slight favour towards CVVHDF (51%) compared to CVVH (41%).[12] In the United Kingdom (UK), CVVH is the dominant mode (56%) compared to CVVHDF (37%).[13] In the United States (US), the pre ATN practice survey conducted in 2003 indicated that 112 (86%) of practitioners prescribed some form of CRRT in the 27 sites

investigated.[11] Of these responders, the majority used CVVHD (78/112), followed by CVVHDF (67/112) with CVVH used in less than a third of patients requiring continuous artificial renal support. It appears from these data that where nephrologists are prescribing and or closely advising intensivists in the US, dialysate or diffusion is a mainstay for the prescription by mode. e.g. CVVHD or CVVHDF.

The use of CVVHDF and CVVH requires the administration of replacement solution. Our data suggests for both these modes that a combination of pre and post dilution replacement is favoured by a third of respondents. Historically, there is variability with some ICUs exclusively using pre or post only sites for substitution. In contrast to our findings, the pre RENAL survey reported 94% of ICUs using a predilution approach in CVVH and CVVHDF, [10] suggesting a change in practice over the past 10 years. The BEST kidney study reported a slight favour for pre dilution (58%) compared to post dilution only (41%).[1] The recent UK[13] and ESICM[12] surveys demonstrated similar findings to our own where a combination of pre and post was most commonly used with typically 30-50% of replacement fluid delivered predilution. It is likely given the technological advancement of the machines used for CRRT that this change in practice may be a common occurrence. Recent machines as cited in this report now have the capacity to deliver replacement fluid both pre and post filter with new software and added roller pumps to achieve this dual pathway simultaneously. Therefore the prescription may simply be because this is possible, or where clotting occurs commonly in the both the filter or membrane and the post filter bubble trap within the circuit, dilution into the blood path targets these two points to prevent clotting : pre and post dilution[17].

Dose

In the pre RENAL practice survey no ANZ ICU reported dosing CRRT according to patient weight. During similar time period there was minimal prescribing of CRRT according to weight in other practice surveys. In the US < 20% of practitioners based the dose on patient weight with the majority (80%) prescribing at least 35 mls/kg/hr.[11] Ricci and colleagues described uncertainty particularly by intensivists to treatment prescription, however indicated a dose of 35 mls/kg/hr or 2-3 L/hr as the target.[16] The BEST study reported treatment doses in mls/hr with a median standardised CRRT dose of 2 L/hr with a calculated weight adjusted dose of 20.4 ml/kg/hr.[1]

A decade on, we report that half the ICUs in ANZ describe a weight based dosing prescription of mls/kg/hr. Further, a CVVHDF dose of 16-25 mls/kg/hr was the most common dose followed by > 25 mls/kg/hr. If CVVH was the mode of choice, a dose of > 25 mls/kg/hr was the most frequently used. For those ANZ ICUs prescribing litres per hour, a dose of 1 L/hr R and 1 L/hr D is the most common in CVVHDF and 2-3 L/hr in CVVH mode. In contrast the ESICM survey described a median CRRT dose of 35 mls/kg/hr with < 15% prescribing a standard fixed ultrafiltrate dose irrespective of body weight.[12] Similar to the European survey, 73% of UK ICUs use a protocol for CRRT dose with a CVVH dose of 35 mls/kg/hr being the most frequent prescription.[13]

Blood Flow Rate

One aspect of practice with ongoing variation is the speed of blood flow in the extracorporeal circuit. Prior to more advanced CRRT technology, blood flow rates of 150-200

ml/min were common. Certainly the ANZ data from 2004[10] indicated a median blood flow rate of 200 ml/min with the BEST kidney study[1] and pre practice ATN study[11] reporting a median rate of 150 ml/min. Interestingly, in the country breakdown Japan median blood flow rate was 80 ml/min whereas Australia, Netherlands, Portugal and the UK median blood flow rate of 200 ml/min. Our study revealed that while 150-200 ml/min was still the dominant setting for all CRRT modes, a faster rate of 200-250 ml/min is now commonplace in the ANZ setting. While we do not have any data on blood flow rates from recent practice surveys, observational studies report practices between 100[18] and > 300[19] ml/min indicating great variability and limited evidence for best practice for this particular setting of the therapy.

Vascular access

Vascular access site for CRRT may be the most important variable for circuit life success. [20-22] As such, there is much literature devoted to access site, type, design and catheter related complications.[23-30] The internal jugular site is traditionally considered to be preferable to femoral venous access[20,31] and supported by ADQI and Kidney Disease Improving Global Outcomes (KDIGO) consensus guidelines.[32,33] Despite this, femoral access catheters are frequently used in the delivery of CRRT[19,26] and may have a lower incidence of dysfunction[26] and colonization compared to jugular position in patients with lower body mass index (BMI).[27] Access site in relation to right and left venous positions have also been investigated with some studies suggesting longer circuit lifespans with right femoral position[25] and right sided internal jugular veins in comparison with a left sided approach.[28] To our knowledge, there is no data to clarify clinicians preference in relation to site, length or type. No previous

or current RRT practice surveys have included vascular access as an item of interest. Our data from ANZ indicates that both right and left femoral veins are the sites of choice followed closely by right internal jugular (IJ) position. An access catheter length of 20 cm is the most common across all sites with just under half respondents indicating 24/25 cm length catheters used in femoral veins. This may reflect that a longer catheter is not considered necessary by some where the 20 cm version can be used in both femoral and IJ sites making ordering and stocking of the device simple. Others using the longer 24 or 25 cm catheter for femoral access in adults, may use this to place the catheter tip closer to the right atrium and would need to order and stock both lengths.

Anticoagulation

Responders to our survey indicate CRRT is often performed without the aid of an anticoagulant agent. When patients received anticoagulation, unfractionated heparin (UFH) was the most common with over 80% of ICU's using this strategy to extend circuit life. This is consistent with previous practice surveys from a decade earlier which also indicated UFH as the anticoagulation of choice.[1,16] This approach is likely to be due to historical and predictable familiar use of this drug within medicine widely. Despite recent studies demonstrating better circuit life and literature guiding CRRT anticoagulation to regional techniques with citrate[34-38] this has not translated into current practice patterns with only a small proportion of responders indicating they frequently use the technique. A lack of historical and familiarity with this agent compared to heparin. Cost may also be a factor where heparin predominates.

Strengths and limitations

A strength of the study is the generalisability of the findings. Despite an unknown response rate, we gathered information from 106 hospitals in ANZ potentially representing 73% of all ICUs capable of performing RRT. This study therefore is the largest investigation of Australian and New Zealand CRRT practice ever conducted.

Our study has several limitations. The accuracy of the responses could not be independently verified as the prescription of CRRT practice was self reported rather than by observation or collection of treatment data. Both pre RENAL[10] and ATN surveys[11] as well as recent practice surveys have used a self report approach. We did not obtain information about the use of, or prescribing practices associated with, alternative renal support therapies such as IHD or SLEDD. Despite some increasing interest in prolonged intermittent therapies such as SLEDD it has been previously reported that patients in ANZ ICUs spend < 5% of their renal support time receiving a therapy other than CRRT.[11] We received 194 responses from 106 ICUs indicating multiple responders from a single ICU and the potential for reporting disagreement. Where multiple responses were received, individual surveys from the site were checked for consistency of practice patterns. For five sites with multiple responses and some inconsistencies in self reported practice, the individual sites were contacted for clarification of usual CRRT prescription in their critical care unit.

Recommendations for research

In this study we chose to determine current practices rather than explore clinicians perceptions of the optimal approaches to CRRT prescription or indeed if they prescribe based on any published evidence at all? It would be useful to explore individual clinician's opinions regarding their practice of the therapy with specific themes of initiation or optimal

timing of CRRT, dose prescription and modality choice for specific patient groups as well as how technical or practical prescription settings are decided in ICUs. In addition a cross sectional study or point prevalence study would provide more objective and reliable data for the prescription and delivery of RRT on ICU inpatients and further highlight consistent or indeed inconsistent current practices associated with renal support in the ANZ context and provide useful data that may help design control groups for future trials. In addition, there is a need to continue developing a data and evidence base for the most effective aspects of CRRT. There also appears to be a need to examine effective strategies for implementing results of past studies into daily practice. Data from large trials published has not changed many aspects of practice in ANZ.

Summary

We conducted a prospective survey of 194 clinicians from 106 ICUs in ANZ on the technical and practical aspects of CRRT prescription. Our findings suggest that a decade on from the last practice survey and the dissemination of 'dose' findings from ANZ there remains high variability in the practical prescription of CRRT. This lack of uniformity particularly in the areas of blood flow rates, access catheter length and replacement fluid site highlight the lack of adequate randomised controlled trials to provide evidence for guidelines associated with these settings. Variability in dose and dose prescription emphasize an inconsistent approach to therapy despite large RCTs and recommendations on the management of CRRT from recently published KDIGO guidelines. This study demonstrates the lack of standardisation in the application of CRRT in the critically ill.

Declaration of conflict of interest

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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Table 1. Profile of Survey respondents (n = 194)

Demographic Variables	Survey Respondents n (%)
State Island or Territory	
Australian Capital Territory	3 (1.5%)
New South Wales	51 (26.3%)
Northern Territory	5 (2.6%)
Queensland	36 (18.6%)
South Australia	18 (9.3%)
Tasmania	5 (2.6%)
Victoria	53 (27.3%)
Western Australia	14 (7.2%)
North Island of New Zealand	8 (4.1%)
South Island of New Zealand	1 (0.5%)
Professional Role	
Consultant Intensivist	36 (18.6%)
NUM (Charge Nurse)	11 (5.7%)
ICU based Educator	37 (19.1%)
Clinical Nurse Consultant	9 (4.6%)
ANUM (Team leader)	12 (6.2%)
Clinical Nurse Specialist	47 (24.2%)
Registered Nurse	42 (21.6%)
Hospital Type	
Regional Hospital	53 (27.3%)
Metropolitan Private Hospital	19 (9.8%)
Metropolitan Public level 2	30 (15.5%)
Metropolitan Public Level 3	92 (47.4%)
ICU Type	
Adult Intensive Care	134 (69.1%)
Paediatric Intensive Care	7 (3.6%)
Combined Adult and Paediatric Intensive Care	53 (27.3%)
ICU bed status	
0-5 beds	8 (4.1%)
6-10 beds	70 (36.1%)
11-15 beds	47 (24.2%)
16-20 beds	22 (11.3%)
> 20 beds	47 (24.2%)
CRRT Yearly Treatments	
< 10	22 (11.3%)
11-25	32 (16.5%)
26-50	44 (22.7%)
51-75	18 (9.3%)
76-100	15 (7.7%)
>100	49 (25.3%)
Don't know	14 (7.2%)

Table 2. CRRT Prescription

CVVHDF (no. + %)	**Never**	**Occasionally**	**Frequently**	**Always**
Dose Prescription (L/hr) (n= 156)				
1L (D) + 1L (R)	60 (38.4%)	35 (22.5%)	51 (32.7%)	10 (6.4%)
1.5L (D) + 1.5L (R)	52 (33.3%)	45 (28.9%)	56 (35.9%)	3 (1.9%)
2L (D) + 2L (R)	61 (39.1%)	55 (35.3%)	30 (19.2%)	10 (6.4%)
>2L (D) + >2L (R)	110 (70.5%)	34 (21.8%)	7 (4.5%)	5 (3.2%)
Dose Prescription (mls/kg/hr) (n= 117)				
0-15 mls/kg	90 (77%)	18 (15.4%)	6 (5.1%)	3 (2.5%)
16-25 mls/kg	27 (23%)	23 (19.7%)	44 (37.6%)	23 (19.7%)
> 25 mls/kg	41 (35%)	30 (25.6%)	31 (26.6%)	15 (12.8%)
Blood Flow rate (mls/min) (n= 177)				
0-50 mls/min	168 (94.9%)	6 (3.4%)	3 (1.7%)	0 (0%)
51-100 mls/min	152 (85.8%)	15 (8.5%)	10 (5.7%)	0 (0%)
101-150 mls/min	85 (48%)	62 (35%)	25 (14.1%)	5 (2.9%)
151-200 mls/min	24 (13.6%)	48 (27.1%)	80 (45.2%)	25 (14.1%)
201-250 mls/min	57 (32.2%)	39 (22.1%)	68 (38.4%)	13 (7.3%)
251-300 mls/min	92 (52%)	44 (24.9%)	35 (19.8%)	6 (3.3%)
> 300 mls/min	155 (87.6%)	17 (9.6%)	2 (1.1%)	3 (1.7%)

CVVH (no. + %)	**Never**	**Occasionally**	**Frequently**	**Always**
Dose Prescription (L/hr) (n= 156)				
≤ 2 litres	116 (74.4%)	29 (18.5%)	4 (2.6%)	7 (4.5%)
> 2 < 3 L	105 (67.3%)	20 (12.8%)	27 (17.3%)	4 (2.6%)
> 3 L	120 (76.9%)	22 (14.1%)	12 (7.7%)	2 (1.3%)
Dose Prescription (mls/kg/hr) (n= 117)				
0-15 mls/kg	108 (92.3%)	8 (6.8%)	1 (0.9%)	0 (0%)
16-25 mls/kg	89 (76%)	17 (14.5%)	9 (7.7%)	2 (1.7%)
> 25 mls/kg	86 (73.5%)	12 (10.3%)	16 (13.7%)	3 (2.5%)
Blood Flow rate (mls/min) (n= 89)				
0-50 mls/min	82 (92%)	5 (5.6%)	2 (2.4%)	0 (0%)
51-100 mls/min	76 (85.4%)	11 (12.3%)	2 (2.3%)	0 (0%)
101-150 mls/min	53 (59.6%)	31 (34.8%)	5 (5.6%)	0 (0%)
151-200 mls/min	17 (19.1%)	19 (21.3%)	38 (42.7%)	15 (16.9%)
201-250 mls/min	25 (28%)	20 (22.5%)	35 (39.3%)	9 (10.2%)
251-300 mls/min	40 (45%)	25 (28%)	21 (23.6%)	3 (3.4%)
> 300 mls/min	74 (83%)	11 (12.4%)	2 (2.3%)	2 (2.3%)

Table 3. Vascular access

Vascular Access	Responses	Never	Occasionally	Frequently	Always
Access Location (n= 194)					
Left Internal Jugular		15 (7.7%)	108 (55.7%)	69 (35.6%)	2 (1.0%)
Right Internal Jugular		7 (3.6%)	65 (33.5%)	121 (62.4%)	1 (0.5%)
Left Femoral		2 (1.0%)	57 (29.4%)	132 (68%)	3 (1.5%)
Right Femoral		3 (1.5%)	51 (26.3%)	137 (70.6%)	3 (1.5%)
Left Subclavian		69 (35.6%)	98 (50.5%)	26 (13.4%)	1 (0.5%)
Right Subclavian		66 (34%)	103 (53.1%)	24 (12.4%)	1 (0.5%)
Access Brand					
Bard Niagara	n= 133	66 (49.6%)	16 (12%)	34 (25.5%)	17 (12.8%)
Gambro Dolphin	n= 136	85 (62.5%)	9 (6.6%)	18 (13.2%)	24 (17.7%)
Quinton Mahurkar	n= 119	114 (95.8%)	4 (3.4%)	1 (0.8%)	0 (0%)
Medcomp	n= 119	110 (92.4%)	0 (0%)	8 (6.7%)	1 (0.8%)
Arrow	n= 137	49 (35.8%)	30 (21.9%)	32 (23.4%)	26 (19%)
Cook	n= 128	84 (65.6%)	17 (13.3%)	19 (14.8%)	8 (6.3%)
Don't Know)(n= 63)					
Vascular Access length (cm)		**15 cm**	**20 cm**	**24/25 cm**	
Internal Jugular	n= 150	94 (62.7%)	55 (36.7%)	1 (0.6%)	
Femoral	n= 150	4 (2.6%)	76 (50.7%)	70 (46.7%)	
Subclavian	n= 150	85 (56.7%)	60 (40%)	5 (3.3%)	
Don't Know (n= 44)					

Figure 1. Anticoagulation for CRRT