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Discrepancies between present guidelines and clinical practice in renal replacement therapy in critically ill patients with acute kidney injury: a Dutch survey

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Abstract. *Objective:* **Acute kidney injury is a common complication of critical illness with high morbidity and mortality. There is no consensus on its optimal management, including renal replacement therapy (RRT). The aim of this survey was to ascertain RRT management in Dutch intensive care units (ICUs), and to evaluate compliance to present guidelines.** *Intervention:* **Questionnaires concerning hospital demographics and RRT management were sent to all ICUs practicing RRT.** *Results:* **ICU physicians and nurses were in charge of RRT in 75% of the ICUs and continuous veno-venous haemofiltration was the preferred modality. A large variability was noted particularly for timing of RRT, but also for dose prescription, anticoagulation strategies and non-renal indications. Only 30% of respondents prescribed the recommended dose of 35 mL/kg/h. The most commonly used anticoagulant was unfractionated heparin. One third of the participating ICUs practiced regional citrate anticoagulation, while 61% were considering implementing it shortly. Danaparoid was the preferred anticoagulation strategy (60%) in patients with heparin-induced thrombocytopenia. The majority of responders (81%) agreed with non-renal indications, including refractory septic shock (48%).** *Conclusions:* **The Dutch practice of RRT is remarkably variable and only partly in line with present guidelines. The high prevalence of regional citrate anticoagulation is in sharp contrast with worldwide practice.**

Keywords: acute Kidney Injury, Continuous renal replacement therapy, intensive care unit, survey

Introduction

Acute kidney injury (AKI) is a frequent complication of critical illness [1]. It is characterized by high morbidity and mortality, particularly if renal replacement therapy (RRT) is required [1]. A recent worldwide survey showed that 4% of intensive care unit (ICU) patients receive RRT, although this incidence varies with the type of patient [1]. The observed mortality of patients with AKI is often higher than predicted based on commonly used scores, particularly when AKI is severe and acute renal failure (ARF) ensues [2]. However, ARF is not only an indicator of severity of disease as there is increasing evidence suggesting that ARF has an independent effect on mortality in critically ill patients [2-4]. Both acute uraemia and unwanted consequences of RRT most probably contribute to this excess mortality.

There is no broad agreement on guidelines for the management of AKI in the critically ill patient, including the use and practice of RRT. Indeed, there is a paucity of randomized-controlled trial (RCT) evidence on the best way to treat these patients. Several controversies exist, including RRT modality, dose and timing, as well as anticoagulation, and non-renal indications. Consequently, there is great variability in the management of RRT [5-7]. Based on a review of the literature and on international guidelines [8-11], the national ICU society in the Netherlands published evidence-based recommendations for management of RRT which are summarized in Table 1 [12,13]. The aim of the present survey was to ascertain practices of RRT in critically ill patients with AKI in the Netherlands, and to evaluate compliance to these guidelines.

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Material and Methods

Surveyed ICUs

First a telephone survey of all Dutch ICUs was performed in order to establish those practicing RRT. Subsequently, these ICUs were sent a questionnaire to be filled in anonymously by the physician with the most responsibility for RRT in his or her ICU. The survey was carried out in the spring of 2007.

The questionnaire

The original questionnaire is shown in the appendix. It consisted of six general multiple-choice questions on the participants' ICU and 26 multiple-choice questions on several aspects of RRT management, including timing, mode, dose, anticoagulation, and non-renal indications. In two of the questions concerning timing and non-renal criteria, the respondents were asked to rank their answers in order of importance. In addition, the respondents were asked how much they agreed with six statements on AKI and RRT using a 100 mm visual analogue scale (VAS) that had ends marked with "disagree" and "agree" [14].

Data presentation and statistical analysis

The questionnaires retrieved were analyzed by means of a Microsoft Access database. Results are presented as absolute numbers, and/or

Table 1 Summary of guidelines [12,13]

Subject	Recommendation
ARF definition	According to the RIFLE classification system
Timing, dose and mode of RRT	
Initiation	Based on the severity of both ARF and other organ failure (grade E). Initiation of RRT is to be considered in oliguric patients (RIFLEO-risk or RIFLEO-Injury), despite adequate fluid resuscitation, and/or persisting steep rise in serum creatinine, in addition to persisting shock (grade E). RRT may be postponed if the underlying disease is improving, other organ failure recovering and the slope in creatinine rise declines, in order to see if renal function is also recovering (grade E)
Discontinuation	RRT should be continued as long as the criteria defining severe oliguria (RIFLEO-Failure) are present (grade E). If the clinical condition improves, waiting may be considered before connecting a new circuit to see whether renal function recovers. RRT should be restarted in clinical or metabolic deterioration
Dose	To achieve a delivered (not prescribed) ultrafiltrate (dialysate) flow during CRRT of 35 mL/kg/h in postdilution (grade A). A higher dose applied for a short time may be considered in sepsis/SIRS (grade E). The dose needs to be adjusted for predilution using the dilution factor, and for filter down time
Mode	In non-shock patients, continuous and intermittent treatments are equivalent regarding survival (level I). However, CRRT is recommended over IHD for patients with ARF who are at risk for cerebral oedema (grade C). CRRT is preferred in the management of patients with ARF and shock (grade E). CRRT should be applied in the veno-venous mode
Anticoagulation Strategies	
Bleeding risk not increased	Use UFH (APTT 1-1,4 times normal) or LMWH (anti-Xa 0.25-0.35 U/mL). When systemic anticoagulation is not indicated regional anticoagulation with citrate may be preferred (grade C-)
Increased bleeding risk	Use regional anticoagulation with citrate (Grade C-). CRRT without anticoagulation can be considered, especially with coagulopathy (grade E). Prostaglandins might be considered (grade E)
Increased clotting tendency	The addition of prostaglandins to UFH or LMWH (grade C), the application of predilution (Grade C), or the combination of systemic anticoagulation with regional citrate can be considered (grade E)
Heparin-induced thrombocytopenia	Stop all kinds of UFH or LMWH (grade C). Use citrate for anticoagulation of the circuit and provide systemic thromboprophylaxis (grade E). The use of danaparoid (anti-Xa 0.25-0.35 U/mL) can be considered if cross-reactivity with heparin-dependent antibodies is excluded (grade E). The use of hirudin should be discouraged (grade E). Potential alternatives are fondaparinux, bivalirudin, argatroban, dermatan sulphate or nafamostat if monitoring is appropriate (grade E). They need further studies since experience in CRRT is still anecdotal

as proportions of participating ICUs. The VAS score was determined by measuring in millimetres from the left-hand end of the line to the point that the participant marked. The results of VAS are presented as mean ± SD.

Results

Responding ICUs

Sixty of 86 questionnaires (70%) were retrieved and suitable for analysis. The participating ICUs included departments in university hospitals (n = 7), teaching hospitals (n = 35) and city or community hospitals (n = 18). The majority of ICUs practiced a closed-format structure (88%). Table 2 summarizes the characteristics of the participating ICUs.

Mode of RRT

Continuous RRT was the preferred modality in all but one centre; a small number of ICUs performed intermittent haemodialysis (IHD) in recovering and stable patients. ICU physicians and nurses were in charge of RRT in more than 70% of responding ICUs (figure 1). Continuous veno-venous haemofiltration (CVVH) was by far the most commonly applied continuous technique, followed by continuous veno-venous haemodiafiltration and continuous veno-venous haemodialysis (figure 2). Pre- and postdilution infusion of substitution fluids were used equally. The majority of the participating ICUs used solely bicarbonate-buffered solutions (62%), while 15% of the ICUs used either bicarbonate-or lactate-buffered solutions, depending on indication (15%). Forty-two percent of ICUs had a CVVH-protocol. . All centres used biocompatible membranes, most frequently polyacrilonitrile and poly(ether)sulphone membranes.

Timing of RRT

There was wide variation in timing criteria (Table 2). Forty-nine of sixty respondents ranked their criteria in order of importance. The top three indications were oligo-anuria, AKI with multiple organ failure, and hyperkalaemia. Urea and creatinine levels were also used as starting criteria, but these criteria were not ranked within the top three criteria. The cut-off starting levels ranged between 25 and 50 mmol/L for urea and between 200 and 650 µmol/L for creatinine. Four centres were participating in a study evaluating the role of serum cystatin-C as criterion for timing of RRT.

The majority of ICUs reported a short delay between prescription and actual initiation of RRT: less than two hours in 85% of the ICUs, and between two and eight hours in 15% of the ICUs. The most frequent causes for delay were shortage of RRT equipment or nursing staff, vascular access problems, or patient transport. Incidentally treatment was delayed for increased bleeding risk (8%). No centre applied strict stopping criteria. Increasing diuresis was the most frequently used criterion for discontinuation of RRT (68%); however, the required threshold urine output varied between 20 and 100 mL/h. In cases of increasing diuresis the majority of participants admitted that they continued RRT until the circuit perished. Another criterion was the urine creatinine level being applied by one third of the participants.

Dose prescription

Dose prescription showed a wide variation among the participants (Figure 3). Dose prescription was seldom adjusted for filter down time (5%), or for the dilution effects of pre-dilution CVVH (3%).

Anticoagulation strategies

Figure 4 shows the various anticoagulation strategies for patients with normal or increased bleeding risk, and patients with suspected or confirmed heparin-induced thrombocytopenia (HIT). In patients without an increased risk of bleeding unfractionated heparin (UFH)

Table 2. Characteristics of participating intensive care units

Number of beds with mechanical ventilation	
0 -10	34 (57%)
10 -20	17 (28%)
20 -30	6 (10%)
30 – 40	3 (5%)
Number of beds without mechanical ventilation	
< 5	45 (75%)
5 -7	12 (20%)
7-10	3 (5%)
Number of patients per ICU physician during the day	
2 - 5	14 (23%)
5 -10	35 (58%)
10 -15	9 (15%)
Unknown	2 (3%)
Number of patients per ICU physician during the night	
> 5	5 (8%)
5 -10	26 (4%)
10 – 20	23 (38%)
20 – 30	4 (7%)
Unknown	2 (3%)
Number of patients in which RRT is initiated per week	
0 -1	38 (63%)
2 – 4	19 (32%)
> 4	3 (5%)
Applied RRT technique	
> 75% CRRT	58 (97%)
> 75% IHD	0
CRRT and IHD are used equally	2 (3%)
Other	0

Results are expressed as absolute numbers and percentage of participating intensive care units (ICU).
CRRT, continuous renal replacement therapy; IHD, intermittent haemodialysis

Table 3. Timing criteria for renal replacement therapy in the critically ill patient with acute kidney injury.

Criteria	number	%
Decreased urine output	14	23
Oligo/anuria (urine output of <500 mL/24 h)	54	90
Metabolic acidosis	47	78
High serum urea level	43	72
High serum creatinine level	21	35
High potassium level	58	97
Steep and persistent rise in serum creatinine level	43	72
Multiple organ failure with acute kidney injury	48	80
Fluid overload	4	7

Participants could tick more than one answer. Results are expressed as absolute numbers and percentage of participating intensive care units (ICU).

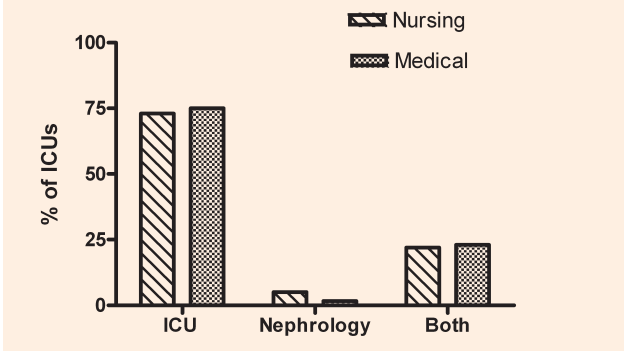

Figure 1. Responsibility for renal replacement therapy in Dutch intensive care units (ICUs) Results are expressed as proportion of participating ICUs (n=60).

was the most commonly used anticoagulant and administered either at a fixed low dose (33%), or titrated to achieve an increased activated partial thromboplastin time (APTT) of ≤ 1.4 (22%) or ≥ 2 (34%). Approximately one quarter of the centres used low molecular weight heparin (LMWH). LMWH was always prescribed at a fixed dose and not based on factor Xa–levels. In patients at increased risk of bleeding the three most commonly used anticoagulation strategies were: a) no anticoagulation, b) regional citrate anticoagulation, (RCA), and c) UHF prescribed at either a fixed low dose (68%), or titrated to achieve an APTT of 40 - 45 seconds (32%). The substitution fluid was preferentially administered before the filter in cases of CVVH without anticoagulation (60%). Approximately one third of the centres routinely applied RCA, and those respondents not yet practicing RCA mentioned they would appreciate training on RCA; 61% of the respondents were considering implementing RCA shortly. In cases of suspected or confirmed HIT, most respondents mentioned danaparoid as being the anticoagulant of first choice. Only a minority of respondents said they would be interested in training on direct thrombin-inhibitors (such as hirudin or argatroban), or other anticoagulants (such as fondaparinux).

Non-renal indications for CRRT

Eighty-two percent of the participating ICUs prescribed CVVH for indications other than ARF. The most popular non-renal indications included intoxications (63%), refractory septic shock (48%), lactate acidosis (33%) and heart failure (25%). Less frequent non-renal indications were acute respiratory distress syndrome (12%) and pancreatitis (7%). Reasons for scepticism included lack of scientific evidence, risks associated with the use of an extracorporeal blood circuit, and high costs. A minority of the participants (15%) mentioned prescribing higher ultrafiltrate doses (4-9.5 L/h) for refractory septic shock.

Visual analogue scale statements on CRRT

Table 3 shows the VAS scores for each of the six statements. It is interesting to see that in a closed ICU concept, the average 'responsible' physician stated that continuous RRT is preferable to intermittent RRT.

Discussion

The practice of RRT in critically ill patients is poorly described. The present survey reports clinical practice amongst Dutch ICUs and evaluates its compliance with national guidelines. Dutch clinical RRT practice is varied and compliance with guidelines is limited, particularly in timing, anticoagulation strategies and non-renal indications. Approximately one third of the respondents prescribed the recommended dose of 35 mL/kg/h [10,12]. However, the centres prescribing 3 and 4 L/h delivered an adequate dose as well. Also 2.5 L/h is in accordance with the guidelines for patients up to 70 kg. Therefore, nearly half of the centres prescribed a dose approximating the dose recommended by the guideline. Notably, dose prescription was seldom adjusted for filter down time and for the dilution effects of pre-dilution CVVH. The recommended dose has been questioned, particularly because in a smaller Dutch randomized study higher doses were shown not to be superior and this may be one of the reasons for the variability in dose prescription [15,16]. The large variability

Table 4. Visual analogue scale (VAS) scores

Statement	VAS score (mean ± SD)
We are in need of a consensus classification system for AKI	7.1 ± 2.3
CRRT is superior to IHD in the critically ill patient with AKI	7.7 ± 1.9
Early timing of RRT is favourable in critically ill patients with AKI	7.0 ± 2.0
In critically ill with AKI the recommended ultrafiltrate dose during CVVH is 35 mL/kg/h in post–dilution	7.4 ± 2.0
Haemofiltration is an effective treatment for sepsis/SIRS due to the removal of toxic mediators	5.4 ± 2.6
The ICU physician should be in charge of RRT in the intensive care	8.2 ± 2.0

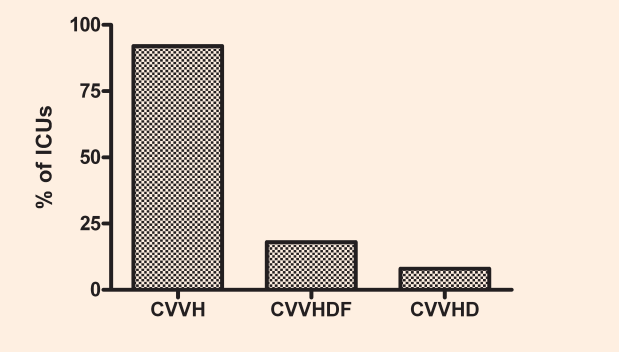

Figure 2. Continuous renal replacement techniques in Dutch intensive care units. Results are expressed as proportion of participating ICUs (n=60). CVVH, continuous veno-venous haemofiltration; CVVHDF, continuous veno-venous haemodiafiltration; CVVHD, continuous veno-venous haemodialysis.

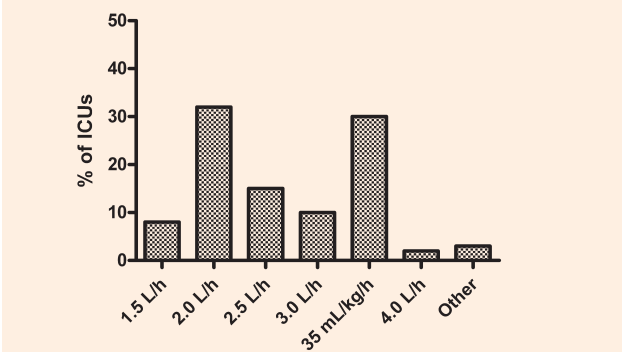

Figure 3. Dose prescription during continuous renal replacement techniques in Dutch intensive care units (ICUs). Results are expressed as proportion of participating ICUs (n=60). Participants could tick more than one answer.

in timing of RRT seems understandable in the light of the absence of sufficient RCT evidence. Non-randomized studies suggest better outcome with early RRT, but are of poor methodological quality. Renal function, however, is unlikely to recover quickly if circulation remains vasopressor dependent, and other organs fail as well. Therefore, in these patients expert opinion suggests early initiation of RRT [12,17]. Notably, we found a delay time between prescription and start of RRT of less than 2 hours in the majority of centres. In most centres ICU-nurses are in charge of RRT activities leading to rapid initiation of RRT. In line with international practice, UFH is the most widely-used anticoagulant in RRT in the Netherlands [6,7]. UFH is given either at a fixed low dose, or aimed at an APTT ranging from 40-80 s. A quarter of the respondents prescribed LMWH. However, in contrast with the recommendations, none of the centres monitor factor Xa–levels routinely most likely because the determination of anti factor Xa–levels is costly and not routinely available in most Dutch hospitals [13,18]. Respondents to our questionnaire mentioned using UFH (36%) or LMWH (10%), even in patients at increased risk of bleeding. These strategies are also contradictory to the recommendations suggesting either RCA or no anticoagulation in patients at increased risk of bleeding [13], but reasons for these practices were not asked for. Variation in the definition of increased risk of bleeding or an indication for systemic anticoagulation may have played a role in the way respondents answered the questions regarding anticoagulation practice. In line with the recommendations, in patients with suspected or confirmed HIT, the majority of the respondents chose either systemic anticoagulation with danaparoid or RCA combined with systemic thromboprophylaxis [13,19]. In patients with HIT all heparins should be stopped; however, alternative systemic anticoagulation is only recommended in patients with proven, or highly suspected thromboembolic complications [19,20]. In our survey no distinction was made between the presence and absence of thrombosis, and this may explain the fact that some participants chose RCA over alternative systemic anticoagulation. Dosing of alternative anticoagulant strategies (heparinoid or direct thrombin inhibitors) is challenging in patients with ARF and continuous RRT, because of the markedly increased half-life resulting in accumulation and bleeding complications [19,21,22]. Notably, the majority of our participants showed no interest in these alternative anticoagulants. This may be due to the fact that HIT is very rare accounting for only 0.3% to 0.5 % of thrombocytopenia in the critical care setting [20]. Remarkably, and despite the lack of sufficient scientific evidence for the use of RRT outside AKI, the majority of our responders also agreed with non-renal indications, including septic shock. The literature at least suggests that haemofiltration with lower volumes is of no benefit for patients with sepsis without ARF [23]. The majority of respondents, however, mentioned that they did not increase their routine RRT dose for non-renal indications.

The results of our survey confirm the results of international surveys showing that RRT practice is not aligned with best evidence, particularly in respect of timing, anticoagulation strategies and non–renal indications. This is understandable because there is little evidence on these subjects. . On the other hand almost half of the centres prescribed the recommended dose and this is not so bad. For more robust recommendations, we need properly designed randomized-controlled trials. One large RCT on dose prescription in critically ill patients with AKI in Australian/New-Zealand is on the way and another large American study was recently published [24,25]. A large European multicentre RCT on the effects of high-volume haemofiltration in septic shock and early AKI is currently recruiting patients, and may bring more insight in the role of high-volume haemofiltration as an adjunctive therapy in sepsis [26]. Notably, the advent of various biomarkers for AKI may help to refine timing criteria in the future [27-29].

The practice of RRT in the Netherlands shows some conspicuous differences with worldwide practice, particularly in preferred modality, responsibility and anticoagulation strategies. In contrast with American practice, here we show CVVH to be the preferred modality, falling largely under the responsibility of ICU physicians and nurses [5]. A predominantly European survey mentioned equal use

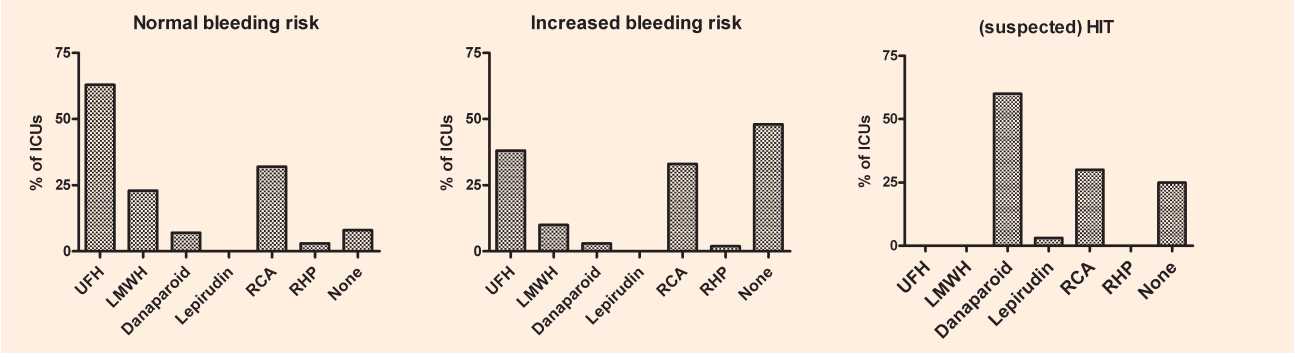

Figure 4. Anticoagulation strategies during continuous renal replacement techniques in Dutch intensive care units (ICUs). Results are expressed as proportion of participating ICUs (n=60). Participants could tick more than one answer. HIT, heparin induced thrombocytopenia; UFH, unfractionated heparin; LMWH, low molecular weight heparin; RCA, regional citrate anticoagulation; RHP, regional heparin-protamin anticoagulation.

of intermittent and continuous techniques; however ICU physicians tended to prefer continuous techniques, while nephrologists more frequently chose IHD [6]. For nearly a decade Australia has almost exclusively been a continuous RRT country [30]. These differences may result from the closed format structure practiced by the majority of Dutch and Australian ICUs.

The popularity of RCA in the Netherlands is another striking difference in comparison with international anticoagulation strategies. Worldwide, the use of RCA is infrequent, possibly related to its metabolic complexity and the fear of complications [6,7]. However, so far studies have shown that RCA is feasible, safe and effective [31-33]. Indeed, we found that one third of the responding ICUs routinely prescribed RCA, even when systemic anticoagulation was not contraindicated. Moreover, almost two-thirds of the participants were considering the implementation of RCA in the near future. The popularity of RCA in the Netherlands is most probably related to several factors including the advent of a Dutch protocol (http://www.nvic.nl/richtlijnen_geaccordeerd.php?id=39&titel=Richtlijn-Regionale-Antistolling-met-Citraat-voor-CVVH), the commercial availability of required solutions and education, and the introduction of modern RRT machines- in which pumps are incorporated for precise and safe infusion of citrate and calcium solutions. Moreover, during the present survey, several ICUs were participating in RCTs, randomizing patients into RCA or heparin treatment [34,35].

Our survey has several limitations. The response rate was 70%. It is therefore likely that there was a self-selection bias towards respondents with particular interest for RRT in the critically ill. In addition we did not independently confirm the data provided. Finally, all the respondents were ICU-physicians, the majority practicing in a closed format ICU. This may have caused bias towards the higher interest in ICU responsibility, continuous techniques and non-renal indications.

Conclusion

In accordance with worldwide practice, Dutch clinical RRT-practice is largely variable and compliance to national guidelines is limited, particularly in relation to timing, anticoagulation strategies and non-renal indications. Continuous veno-venous haemofiltration is the preferred mode in the Netherlands falling mainly under the responsibility of ICU physicians and nurses. The popularity of RCA in the Netherlands contrasts with the limited RCA application internationally.

Acknowledgements

We thank all the respondents for their time and effort in participating in this survey.

Competing interest

CSC Bouman contributed to the Dutch guidelines on timing, dose and mode of CRRT for ARF in the critically ill [12].

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Dutch questionnaire

Renal Replacement Therapy in Intensive Care

Questionnaire renal replacement therapy on the intensive care

This questionnaire consists of three sections (A, B, C).

Section A: General

This section seeks information about your working environment.

Section B: Continuous Renal Replacement therapy (CRRT)

This section seeks information on the clinical practice of CRRT on your intensive care unit. This section is to be filled in only if you predominantly (>75%) use CRRT on your intensive care.

Section C: Intermittent Haemodialysis (IHD)

This section seeks information on the clinical practice of IHD on your intensive care unit. This section is to be filled in only if you predominantly (>75%) use IHD or Slow Extended Daily Dialysis (SLEDD).

If your intensive care unit uses CRRT and IHD equally, please fill in both sections B and C.

We greatly appreciate you completing this survey and thank you in advance for your time.

Section A
General

1 Hospital?
- ☐ University hospital
- ☐ Teaching hospital
- ☐ Community hospital

2 Number of ICU beds?

___ beds with mechanical ventilation

___ beds without mechanical ventilation

3 Format?
- ☐ Closed format ICU
- ☐ Open format ICU

4 Number of patients per doctor during the day?

_____

5 Number of patients per doctor during the night?

_____

6 How many new renal replacement treatments per week?
- ☐ 0 – 1
- ☐ 2 – 4
- ☐ > 4

Section B
Continuous Renal Replacement therapy

This section is to be filled in only if you predominantly (>75%) use CRRT on your intensive care.
More than one answer can be ticked (left-hand column). When specified, rank in order of importance (right-hand column).

1 Why do you predominantly use CRRT?
- ☐ CRRT is the preferred mode in critically ill patients.
- ☐ Intermittent haemodialysis is not available in our hospital
- ☐ Logistical reasons (e.g. CRRT is more rapidly initiated)
- ☐ Other _____

2 How many CRRT machines are at your disposal?

___ machines

3 CRRT is generally prescribed by the medical staff of:
- ☐ Intensive Care
- ☐ Nephrology
- ☐ Both

4 Are you satisfied with the above-mentioned approach?
- ☐ Yes
- ☐ No, intensive care should be in charge
- ☐ No, nephrology should be in charge
- ☐ No, intensive care and nephrology should both be in charge

5 Who is in charge of the CRRT nursing tasks?
- ☐ ICU nurse
- ☐ Dialysis nurse
- ☐ Both

6 Do you use CRRT for anything other than renal indications?
- ☐ No
- ☐ Yes

The questions 7 up to 12 concern timing (initiation and discontinuation) of CRRT in critically ill patients with acute kidney injury

7 Starting criteria? *Rank in order of importance (right-hand column).*
- ☐ Decreased urine output ☐
- ☐ Oligo-anuria (< 500 ml/24h) ☐
- ☐ Metabolic acidosis ☐
- ☐ Increased serum urea above ___ mmol/L ☐
- ☐ Increased serum creatinine above __ µmol/IL ☐
- ☐ Hyperkalaemia (> 6.5 mmol/L) ☐
- ☐ Steep and persistent rise in serum creatinine ☐
- ☐ Acute kidney injury as part of multiple organ failure ☐
- ☐ Other _____

8 Do you sometimes withhold CRRT despite fullfillment of above mentioned starting criteria?
- ☐ Yes, high risk due to anticoagulation
- ☐ Yes, high risk due to haemodynamic instability
- ☐ Yes, risks related to vascular access
- ☐ No
- ☐ Other _____

9 What is the average delay time between prescription and initiation of CRRT?
- ☐ No delay, CRRT is started immediately
- ☐ < 2 hrs
- ☐ 2 - 8 hrs
- ☐ 8 -12 hrs
- ☐ > 12 hrs

10 What are the most frequent causes of a delay time of > 8 hrs? *Rank in order of importance (right-hand column)*
- ☐ No CRRT machines available ☐
- ☐ No nurses available ☐
- ☐ No vascular access ☐
- ☐ Transport ☐
- ☐ Other _____ ☐

11 Discontinuation criteria?
- ☐ Increased urine output above _____ ml/hrs
  - ☐ CRRT is stopped:
  - ☐ Immediately
  - ☐ When the system perishes
- ☐ We stop CRRT routinely every _____ days
- ☐ Increased urine creatinine level
- ☐ Other _____

12 Do you have a protocol for timing of CRRT?
- ☐ Yes
- ☐ No

Questions 13 to 20 concern the mode of CRRT on your intensive care unit

13 Mode?
- ☐ Continuous veno-venous haemofiltration (CVVH)
  - ☐ Postdilution
  - ☐ Predilution
  - ☐ Both, but predominantly postdilution
  - ☐ Both, but predominantly predilution
  - ☐ Both equally often
- ☐ Continuous veno-venous haemodiafiltration (CVVHDF)
  - ☐ Postdilution
  - ☐ Predilution
  - ☐ Both, but predominantly postdilution
  - ☐ Both, but predominantly predilution
  - ☐ Both equally often
- ☐ Continue veno-venous haemodialysis (CVVHD)
- ☐ Other _____

14 Predominantly used replacement solution?
- ☐ Bicarbonate-based solution
- ☐ Lactate-based solution

- ☐ Bicarbonate and lactate equally often
- ☐ Other _____

15 Predominantly used haemofilter?
- ☐ Cellulose membrane
- ☐ Modified cellulose membrane
- ☐ Synthetic membrane, _____
- ☐ I don't know

16 Anticoagulant if bleeding risk is normal?
- ☐ Unfractionated heparin
  - ☐ fixed low dose (≤ 500 U/h)
  - ☐ increase APTT ≤ 1.4
  - ☐ increase APTT ≤ 2
- ☐ Low molecular weight heparin
  - ☐ anti-Xa monitoring (0.25-0.35 U/ml)
  - ☐ No anti-Xa monitoring
- ☐ Danaparoid
- ☐ Lepirudin
- ☐ Regional citrate anticoagulation
- ☐ Regional heparin–protamin anticoagulation
- ☐ No anticoagulation
- ☐ Other, _____

17 Anticoagulant if bleeding risk is increased?
- ☐ Unfractionated heparin
  - ☐ fixed low dose (ffi 500 U/h)
  - ☐ increase APTT ffi 1.4
  - ☐ increase APTT ffl 2
- ☐ Low molecular weight heparin
  - ☐ anti-Xa monitoring (0.25-0.35 U/ml)
  - ☐ No anti-Xa monitoring
- ☐ Danaparoid
- ☐ Lepirudin
- ☐ Regional citrate anticoagulation
- ☐ Regional heparin-protamin anticoagulation
- ☐ No anticoagulation
- ☐ Other, _____

18 Anticoagulant in patient with heparin-induced thrombocytopenia?
- ☐ Unfractionated heparin
  - ☐ fixed low dose (ffi 500 U/h)
  - ☐ increase APTT ffi 1.4
  - ☐ increase APTT ffl 2
- ☐ Low molecular weight heparin
  - ☐ anti-Xa monitoring (0.25-0.35 U/ml)
  - ☐ No anti-Xa monitoring
- ☐ Danaparoid
- ☐ Lepirudin
- ☐ Regional citrate anticoagulation
- ☐ Regional heparin-protamin anticoagulation
- ☐ No anticoagulation
- ☐ Other, _____

19 Alternative strategies if clotting tendency is increased?
- ☐ None
- ☐ Predilution mode
- ☐ Heparin-coated membranes
- ☐ Priming with anticoagulant-containing solution
- ☐ Priming with albumin-containing solution
- ☐ Saline flushing
- ☐ Other _____

20 Are you interested in, or have you considered the implementation of alternative anticoagulants (e.g. fondaparinux, argatroban)?
- ☐ No
- ☐ Yes _____

Questions 21 to 24 concern dosing of renal replacement therapy in critically patients with acute kidney injury.

21 Which ultrafiltrate flow do you predominantly use?
- ☐ 35 ml/kg/h
- ☐ 1.5 L/h
- ☐ 2.0 L/h
- ☐ 2.5 L/h
- ☐ 3.0 L/h
- ☐ Other _____
- ☐ I don't know
- ☐ We only use CVVHD

22 Which dialysate flow do you predominantly use?
- ☐ 35 ml/kg/h
- ☐ 1.5 L/h
- ☐ 2.0 L/h
- ☐ 2.5 L/h
- ☐ 3.0 L/h
- ☐ Other _____
- ☐ I don't know
- ☐ We only use CVVH

23 Do you correct the dose for filter down time?
- ☐ Yes
- ☐ No

24 Do you correct the dose for predilution?
- ☐ Yes
- ☐ No

Questions 25 to 27 concern non-renal indications.

25 Which non-renal indications do you use? *Rank in order of importance*

☐ Refractory septic shock	☐
☐ Congestive heart failure	☐
☐ ARDS	☐
☐ Liver failure	☐
☐ Pancreatitis	☐
☐ Lactate acidosis	☐
☐ Drug intoxications	☐
☐ Out-of-hospital cardiac arrest	☐
☐ None	☐
☐ Other _____	☐

26 Why do you disagree with the initiation of CRRT in other than renal indications?
- ☐ Risk due to anticoagulation
- ☐ Risk due to haemodynamic instability
- ☐ Risk related to vascular access
- ☐ Lack of scientific evidence
- ☐ High costs
- ☐ Risk of blood loss in the extracorporeal system
- ☐ Risk related to vascular access
- ☐ Other _____

27 Do you use the 'renal' ultrafiltrate dose in refractory septic shock?
- ☐ No ____ ml/hrs
- ☐ Yes

Draw a vertical line to indicate the extent to which you agree with the following statements

Example

Disagree — Agree

0 — 10

S1 We are in need of a consensus classification system for AKI

Disagree — Agree

0 — 10

S2 CRRT is superior to IHD in the critically ill patient with AKI

Disagree — Agree

0 — 10

S3 Early timing of RRT is favourable in critically ill patients with AKI

Disagree — Agree

0 — 10

S4 In the critically ill with AKI the recommended ultrafiltrate dose during CVVH is 35 mL/kg/h

Disagree — Agree

0 — 10

S5 Haemofiltration is an effective treatment for sepsis/SIRS due to the removal of mediators

Disagree — Agree

0 — 10

S6 The ICU physician should be in charge of RRT in the ICU

Disagree — Agree

0 — 10

Section C
Intermittent Haemodialysis (IHD)

This section is to be filled in only if you predominantly (>75%) use IHD or SLEDD on your intensive care.

More than one answer can be ticked (left-hand column). When specified, rank in order of importance (right-hand column).

1 Why do you predominantly use IHD?
- ☐ IHD is the preferred mode in critically ill patients
- ☐ CRRT is not available in our hospital
- ☐ Other ...

The questions 2 up to 8 concern timing (initiation and discontinuation) of IHD in critically ill patients with acute kidney injury

2 Starting criteria? *Rank in order of importance (right column).*
- ☐ Decreased urine output ☐
- ☐ Oligo-anuria (< 500 ml/24h) ☐
- ☐ Metabolic acidosis ☐
- ☐ Increased serum urea above ___ mmol/L ☐
- ☐ Increased serum creatinine above ___ µmol/lL ☐
- ☐ Hyperkalaemia (> 6.5 mmol/L) ☐
- ☐ Steep and persistent rise in serum creatinine ☐
- ☐ Acute kidney injury as part of multiple organ failure ☐
- ☐ Other _____ ☐

3 Do you have a protocol for timing of IHD?
- ☐ Yes
- ☐ No

4 Do you sometimes withhold IHD despite fullfillment of above-mentioned starting criteria?
- ☐ Yes, high risk due to anticoagulation
- ☐ Yes, high risk due to haemodynamic instability
- ☐ Yes, risks related to vascular access
- ☐ No
- ☐ Other _____

5 What is the average delay-time between prescription and initiation of IHD?
- ☐ No delay, IHD is started immediately
- ☐ < 2 hrs
- ☐ 2 - 8 hrs
- ☐ 8 -12 hrs
- ☐ > 12 hrs

6 What are the most frequent causes for a delay time of > 8 hrs? *Rank in order of importance (right column)*
- ☐ No IHD machines available
- ☐ No staff available
- ☐ No vascular access
- ☐ Transport
- ☐ Other _____

7 IHD is generally prescribed by the medical staff by
- ☐ Intensive Care
- ☐ Nephrology
- ☐ Both

8 Are you satisfied with the above mentioned organization?
- ☐ Yes
- ☐ No, intensive care should be in charge
- ☐ No, nephrology should be in charge
- ☐ No, intensive care and nephrology should both be in charge

Questions 9 to 11 concern mode and dose of IHD on your ICU

9 Predominantly used haemofilter?
- ☐ Cellulose membrane
- ☐ Modified cellulose membrane
- ☐ Synthetic membrane, _____
- ☐ I don't know

10 Frequency IHD?
- ☐ Daily
- ☐ 3 /week
- ☐ 2 /week
- ☐ Variable, but on average: _____ per week

11 Average duration IHD?
- ☐ 2 hrs
- ☐ 3 hrs
- ☐ 4 hrs
- ☐ 5 hrs
- ☐ Other _____

12 Are you familiar with SLEDD (Slow Extended Daily Dialysis)?
- ☐ Yes, but we do not use it on our ICU
- ☐ Yes and we regularly use it on our ICU
- ☐ No

Please fill in the 6 VAS statements on page 12