Baxter

Managing Patient Temperature During CRRT

Presentation Overview

- Importance of patient temperature management
- CRRT-induced hypothermia
- Homeostasis and core body temperature regulation
- Physiological consequences of hypothermia
- Hypothermia impact on morbidity and mortality
- Preventing CRRT-induced hypothermia
- **PRISMFLO** IIS Blood Warmer
- Recommendations
- References

USMP/MG120/19-0013 05/19

Importance of Patient Temperature Management

USMP/MG120/19-0013 05/19

Why Is Patient Temperature Management Important?

- Hypothermia occurs in 40-50% of CRRT patients[1-2]
- CRRT-induced hypothermia is caused by
  - Exposure of blood in the extracorporeal circuit to ambient temperature for prolonged periods of time[3-4]
  - Administration of cool dialysate and/or replacement fluids[3-4]
- Hypothermia risk is increased by sedation, immobility, paralytic drugs, sepsis, underlying endocrine disorders, and higher CRRT dose[3-4]
- Unintentional hypothermia has negative clinical consequences[3-4]

1. Akhoundi A et al. Blood Purif. 2015;39(4):333-9.
2. Yagi N et al. Am J Kidney Dis. 1998 Dec;32(6):1023-30.
3. Kaur G et al. Hemodial Int. 2017 Oct;21 Suppl 2:S57-S61.
4. Jones S. AACN Clin Issues. 2004 Apr-Jun;15(2):223-30.

USMP/MG120/19-0013 05/19

Baxter

CRRT-Induced Hypothermia

USMP/MG120/19-0013 05/19

CRRT-Induced Hypothermia Occurs Frequently

- Retrospective study of 595 consecutive CRRT patients
  - 98% CVVH, median duration 4 days
- Replacement fluids were warmed to 38.9 °C (use of online fluid warmer was added if temperature declined)
- Median core temperature decreased by 1.7 °C following institution of CRRT
  - Pre CRRT: 36.9 °C
  - During CRRT: 35.2 °C
- 44% of patients exhibited significant hypothermia (core temperature <35 °C)

Table 2. Adverse events

Catheter-related complication, n (%)	225 (38)
Bleeding	134 (23)
Arterial puncture	6 (1)
Hematoma	17 (2.85)
Other	71 (11.93)
Line-related infection*	30 (5)
SAEs, n (%)	573 (97)
First-hour hypotension	258 (43)
Significant hypothermia (<35°C)	259 (44)
New onset anemia-Hgb <10 g/dL	179 (31)
New onset thrombocytopenia (<50% baseline) with baseline platelet >150,000	73 (13)
New onset thrombocytopenia (<50% baseline) with baseline platelet <150,000	143 (26)
Arrhythmia, n (%)	484 (81)
Sinus tachycardia	306 (51)
Atrial fibrillation	64 (11)
Atrial flutter	6 (1)
Ventricular tachycardia	14 (2)
Sinus bradycardia	43 (7)
Ventricular fibrillation	19 (3)
Asystole	20 (3)
Others	12 (2)
CPR	28 (5)

SAE = Severe adverse event; Hgb = hemoglobin; CPR = cardiopulmonary resuscitation. * Both dialysis and central venous catheters.

Akhoundi A et al. Blood Purif. 2015;39(4):333-9.

Baxter

Cooling Effect of CRRT in Critically Ill Patients

1. **Retrospective review**
- 72 consecutive CRRT patients
- Room temperature dialysate & replacement fluids
- Hypothermia observed in 38% of sessions
- Hypothermia > frequent in venovenous modalities
- Hypothermia occurred in almost 50% of CVVHD patients

2. **Prospective study**
- 27 CVVHD patients
- Room temperature dialysate
- Circuit blood and dialysate temperatures measured at varying flow rates
- 52% of patients experienced hypothermia
- Thermal energy loss was increased with slower blood flow rate and faster dialysate rate

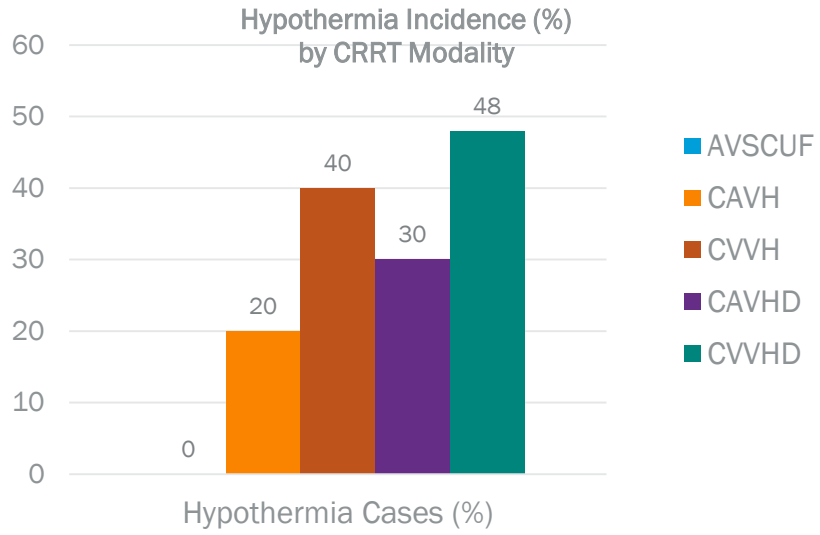


Table 5. Energy Loss during CRRT

Dialysate Flow	Blood Flow (mL/min) 100	150	200	*P*
500 mL/hr	1.2 ± 0.3 kj/min	0.9 ± 0.2 kj/min	0.7 ± 0.2 kj/min	<0.001
1,000 mL/hr	2.5 ± 0.5 kj/min	1.8 ± 0.4 kj/min	1.4 ± 0.4 kj/min	<0.001
1,500 mL/hr	4.1 ± 0.4 kj/min	3.1 ± 0.7 kj/min	2.4 ± 0.6 kj/min	<0.001
P	<0.001	<0.001	<0.001	

NOTE. Energy loss was influenced by both Qb and Qd. The faster the Qd or the lower the Qb, the greater the energy loss ($P < 0.001$).

Yagi N et al. Am J Kidney Dis. 1998 Dec;32(6):1023-30

Homeostasis and Temperature Regulation

Core body temperature is tightly regulated around 37 °C[1-2]

Small increases in core temperature → heat dissipation[1-2]

- Sweating and vasodilation

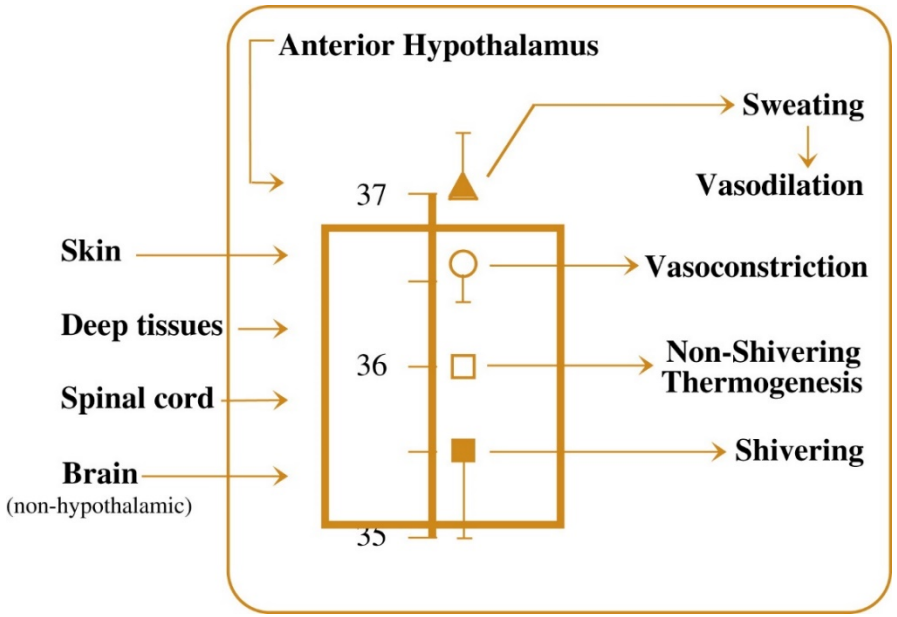
Small decreases in core temperature → heat conservation[1-2]

- Vasoconstriction

Additional decreases in core temperature → heat generation[1-2]

- Shivering

Thermoregulatory Responses to Deviations from Core Body Temperature[2]



1. Jones S. AACN Clin Issues. 2004 Apr-Jun;15(2):223-30.
2. Kurz A. Best Pract Res Clin Anaesthesiol. 2008 Dec;22(4):627-44

USMP/MG120/19-0013 05/19

Baxter

Shivering

- Stimulated by heat receptors in the brain, skin and spinal cord in response to heat loss or sudden cold exposure[1]
- Increases body temperature through muscle contractions[1]
- Muscle contractions significantly increase caloric expenditure and oxygen requirements[1]
- Metabolic rate increases with shivering intensity[1-2]
- May increase oxygen requirements by 300-400%[1,3]
- Cardiac and caloric costs of shivering are not well tolerated by the already fragile critically ill patient[1]

Metabolic rate increases with shivering intensity[2]

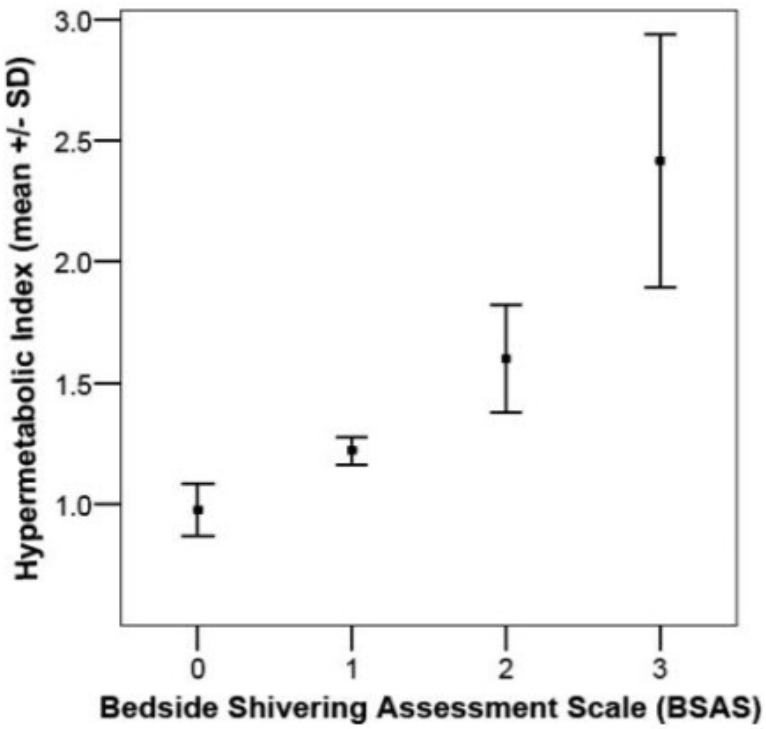


Figure. Relationship between the BSAS and the HMI.

BSAS

0 – None: no shivering
1 – Mild: localized to neck and/or thorax only
2 – Moderate: gross movement of upper extremities
3 – Severe: gross movements of trunk + upper/lower extremities

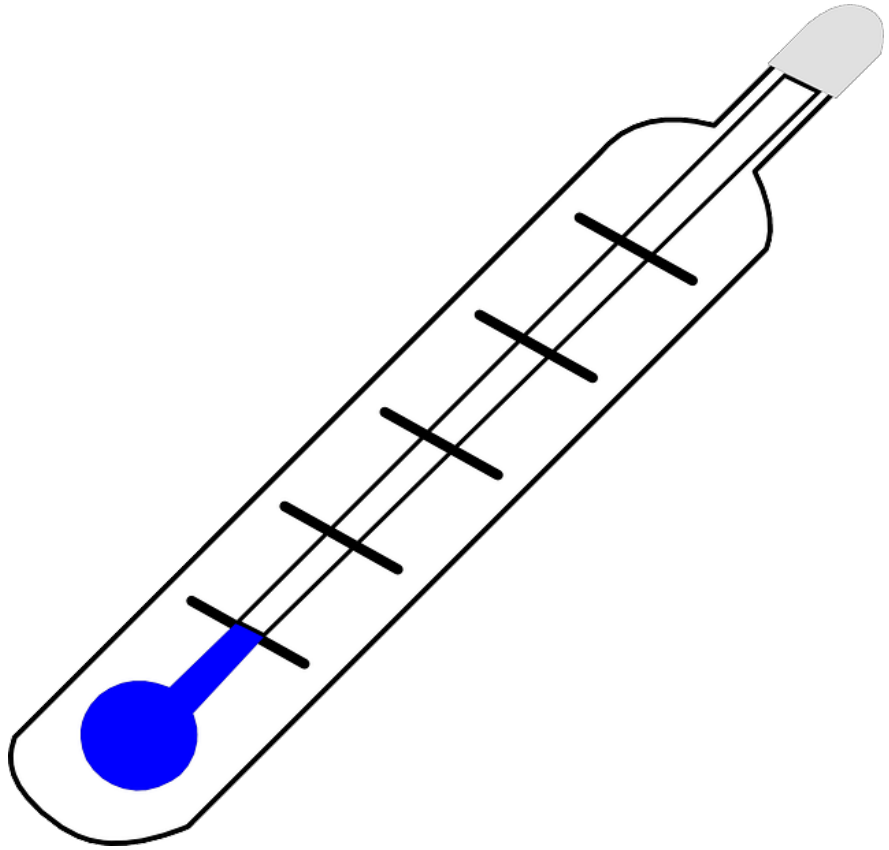
1. Jones S. AACN Clin Issues. 2004 Apr-Jun;15(2):223-30.
2. Badjatia N et al. Stroke. 2008 Dec;39(12):3242-7.
3. Sessler DI. Anesthesiology. 2001 Aug;95(2):531-43.

USMP/MG120/19-0013 05/19

Baxter

Hypothermia Signs & Symptoms

- Body temperature below normal range
- Cool, pale skin
- Dizziness
- Hypertension
- Increased heart rate
- Lack of coordination
- Shivering



Farley A & McLafferty E. Nurs Stand. 2008 Jan 2-8;22(17):43-6.

USMP/MG120/19-0013 05/19

Baxter

Adverse Impact of Hypothermia

- Increased oxygen demand[1-3]
- Hypoxemia[1-2]
- Myocardial ischemia[1-2]
- Changes in cardiac conduction[1-2]
- Coagulation disorders[2]
- Deterioration in immune response[1-3]
- Increased risk of infection, delayed wound healing[2]
- May mask the presence of fever/infection[3]
- Patient discomfort[2]

1. Jones S. AACN Clin Issues. 2004 Apr-Jun;15(2):223-30.
2. Sessler DI. Complications and treatment of mild hypothermia. Anesthesiology. 2001 Aug;95(2):531-43.
3. Ricci Z & Romagnoli S. Contrib Nephrol. 2018;194:99-108.

USMP/MG120/19-0013 05/19

Baxter

Inadvertent Hypothermia Increases ICU Mortality

Meta-analysis: 18 studies

- Inadvertent (unintentional) hypothermia significantly increases ICU mortality
- Mortality doubled when hypothermia was defined as <36.0°C
  - Pooled OR 2.09; 95% CI, 1.70–2.57
- Mortality tripled when hypothermia was defined as <35.0°C
  - Pooled OR 2.95; 95% CI, 2.17–4.00

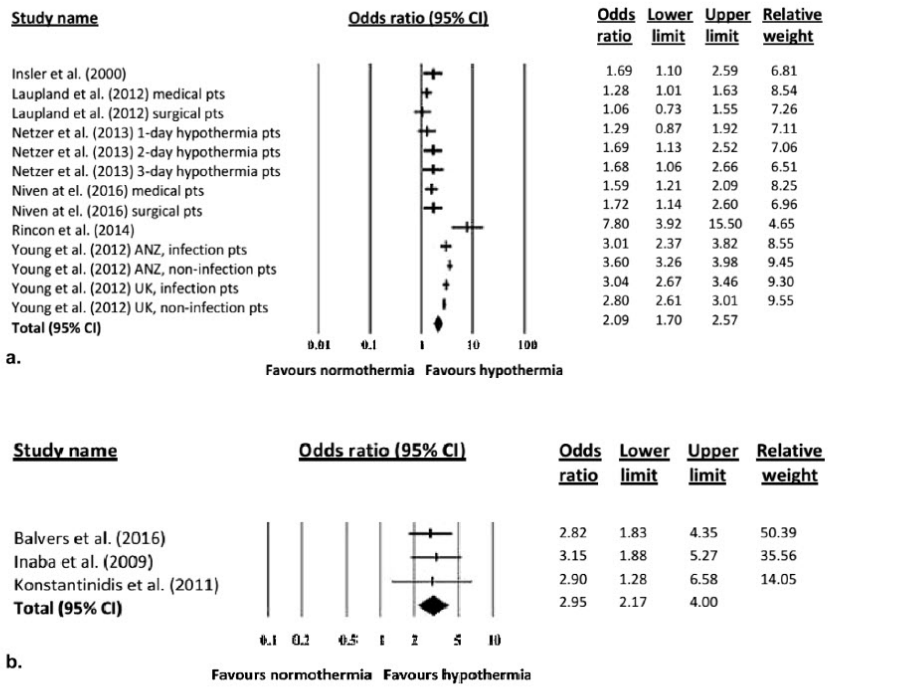


Fig. 3. Forest plots depicting adjusted odds ratios for mortality (with 95% confidence intervals) according to inadvertent hypothermia, (a) hypothermia defined as core temperature <36.0°C, (b) hypothermia defined as core temperature <35.0°C.
pts, patients; CI, confidence interval.

Kiekkas P et al. Aust Crit Care. 2018 Jan;31(1):12-22

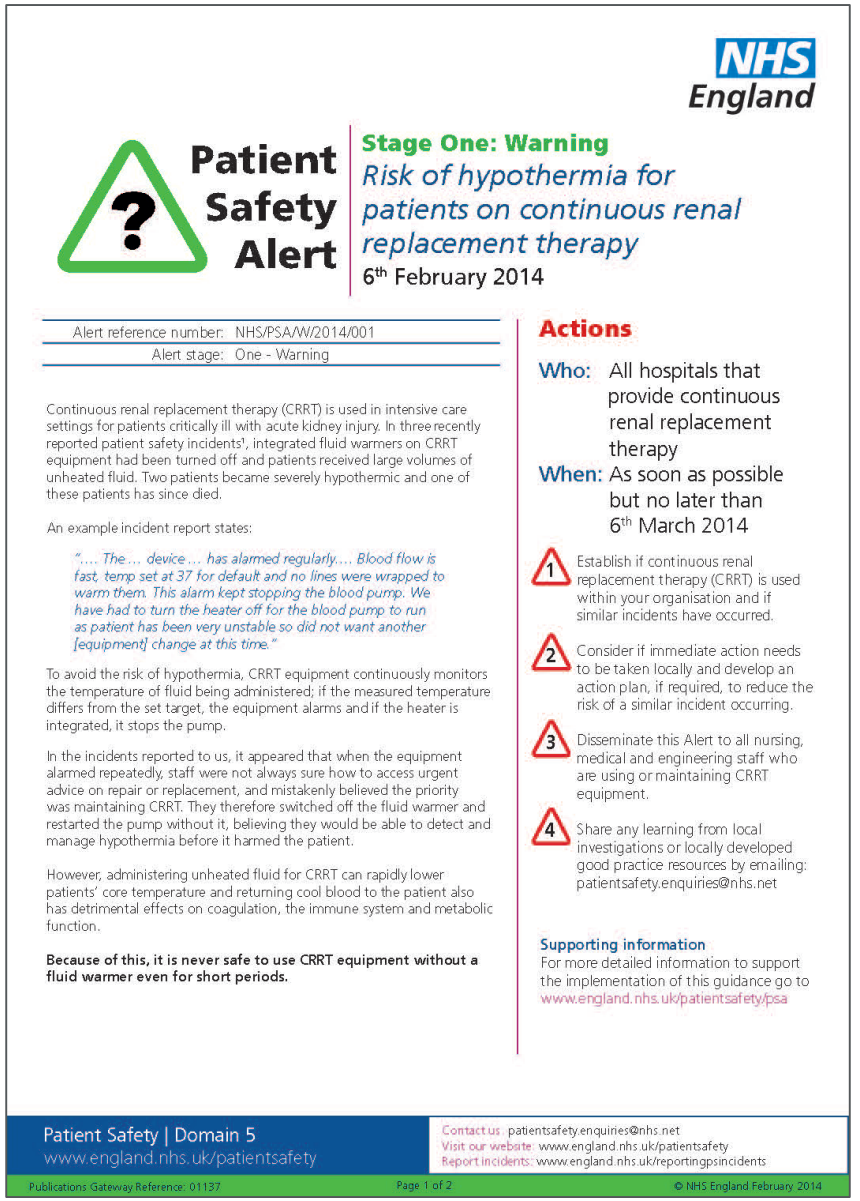
USMP/MG120/19-0013 05/19

Baxter

UK NHS Warning: CRRT Hypothermia

Patient Safety Alert issued by NHS in 2014

- Response to 3 incidents in which integrated fluid warmers were switched off and patients received "large volumes of unheated fluid"
- 2 patients experienced severe hypothermia, 1 of whom died
- "…administering unheated fluid for CRRT can rapidly lower patients' core temperature and returning cool blood to the patient also has detrimental effects on coagulation, the immune system and metabolic function"



NHS England

Patient Safety Alert

Stage One: Warning

Risk of hypothermia for patients on continuous renal replacement therapy

6th February 2014

Alert reference number: NHS/PSA/W/2014/001
Alert stage: One - Warning

Continuous renal replacement therapy (CRRT) is used in intensive care settings for patients critically ill with acute kidney injury. In three recently reported patient safety incidents[1], integrated fluid warmers on CRRT equipment had been turned off and patients received large volumes of unheated fluid. Two patients became severely hypothermic and one of these patients has since died.

An example incident report states:

"…. The … device … has alarmed regularly…. Blood flow is fast, temp set at 37 for default and no lines were wrapped to warm them. This alarm kept stopping the blood pump. We have had to turn the heater off for the blood pump to run as patient has been very unstable so did not want another [equipment] change at this time."

To avoid the risk of hypothermia, CRRT equipment continuously monitors the temperature of fluid being administered; if the measured temperature differs from the set target, the equipment alarms and if the heater is integrated, it stops the pump.

In the incidents reported to us, it appeared that when the equipment alarmed repeatedly, staff were not always sure how to access urgent advice on repair or replacement, and mistakenly believed the priority was maintaining CRRT. They therefore switched off the fluid warmer and restarted the pump without it, believing they would be able to detect and manage hypothermia before it harmed the patient.

However, administering unheated fluid for CRRT can rapidly lower patients' core temperature and returning cool blood to the patient also has detrimental effects on coagulation, the immune system and metabolic function.

Because of this, it is never safe to use CRRT equipment without a fluid warmer even for short periods.

Actions

Who: All hospitals that provide continuous renal replacement therapy

When: As soon as possible but no later than 6th March 2014

1. Establish if continuous renal replacement therapy (CRRT) is used within your organisation and if similar incidents have occurred.
2. Consider if immediate action needs to be taken locally and develop an action plan, if required, to reduce the risk of a similar incident occurring.
3. Disseminate this Alert to all nursing, medical and engineering staff who are using or maintaining CRRT equipment.
4. Share any learning from local investigations or locally developed good practice resources by emailing: patientsafety.enquiries@nhs.net

Supporting information

For more detailed information to support the implementation of this guidance go to www.england.nhs.uk/patientsafety/psa

Patient Safety | Domain 5
www.england.nhs.uk/patientsafety

Contact us: patientsafety.enquiries@nhs.net
Visit our website: www.england.nhs.uk/patientsafety
Report incidents: www.england.nhs.uk/reportingpsincidents

Publications Gateway Reference: 01137 Page 1 of 2 © NHS England February 2014

NHS England. Patient Safety Alert. February 6 2014.
https://improvement.nhs.uk/documents/976/hypothermia.pdf

Minimizing CRRT-Induced Hypothermia

USMP/MG120/19-0013 05/19

IV Fluid Warming Does Not Prevent Hypothermia

- Randomized controlled trial to evaluate effectiveness of fluid warmers in preventing hypothermia during CVVHDF
- 60 circuits randomized to IV fluid warmer set at 38.5°C vs. no fluid warmer
- Patient core temperature was recorded at baseline, then hourly
- Hypothermia was defined as a core temperature <36.0°C
- Mean core temperature loss did not differ between patients treated with vs. without use of fluid warmer
  - 0.92°C vs. 1.11°C, P = 0.339
- Hypothermia incidence did not differ between patients treated with vs. without use of fluid warmer (P = 0.491)

Table 2 Patient core temperature data (°C)

	Fluid warmer	No fluid warmer	Total	*P* value
Baseline (mean)	37·49	37·65	37·57	0·41
Minimum (mean)	36·57	36·54	36·56	0·87
Temperature loss (mean)	0·92	1·11	1·01	0·34

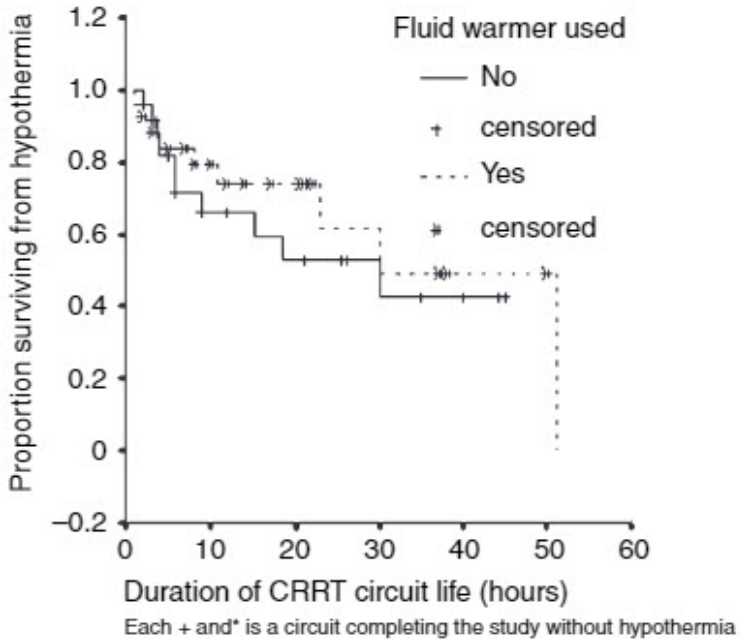


Figure 2 Survival from hypothermia by fluid warmer (Kaplan–Meier).

Rickard CM et al. J Adv Nurs. 2004 Aug;47(4):393-400.

Baxter

PRISMAFLO IIS Blood Warmer

- Used with the **PRISMAFLEX** System
- **PRISMAFLEX** System return line is inserted into the groove of the flexible heating sleeve
- Patient's return blood flow is warmed efficiently, with no increase of extracorporeal blood volume
- Independent sensors monitor temperature for patient safety
- Digital interface shows actual and set temperatures
- Integrated self-test is included

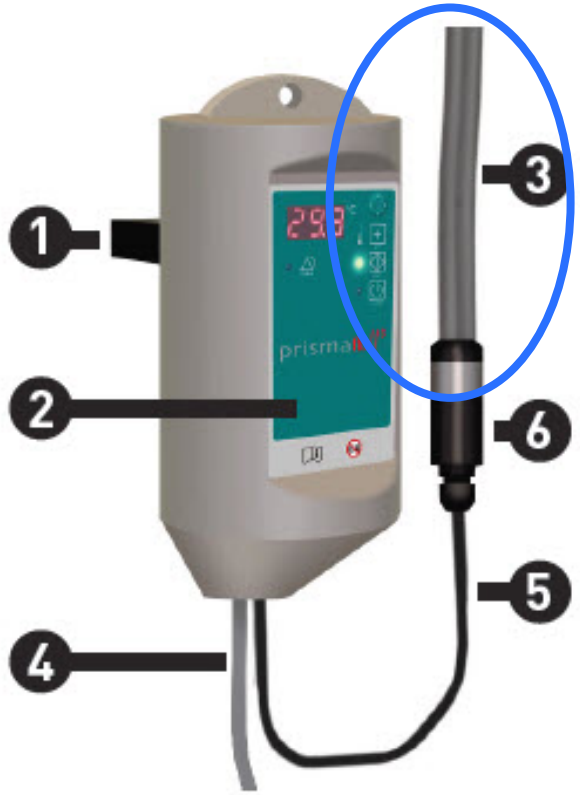
PRISMAFLO IIS System Specification Sheet. 306100438_1 c 2013.07. Gambro Lundia AB.

USMP/MG120/19-0013 05/19

Baxter

PRISMAFLO IIS Heating Sleeve

It is important to ensure that the **PRISMAFLO** IIS Heating Sleeve is dried thoroughly after cleaning



1. Attachment Device: Attaches the PRISMAFLO IIS Blood Warmer to the holder, which is mounted on the backside of the PRISMAFLEX Control Unit
2. Control Panel: Control buttons and indicators
3. Flexible Heating Sleeve: Transfers heat from the internal heating wire to the medium to be warmed via the inserted blood return line
4. Power Supply Cord: Supplies electricity from the socket to the control unit
5. Connection Cable Heating Sleeve: Connection between control unit and changeable heating sleeve
6. Adaptor of Heating Sleeve: Connection between heating sleeve and cable.

PRISMAFLO IIS Quick User Guide. USMP/MG142/16-0002 1000 02/16.

Baxter

Additional External Warming Is Recommended

CRRT device heating modules may be insufficient to prevent hypothermia, particularly at high doses

- ***Passive external rewarming*** (covering patient with blankets)
  - Allows normal thermogenesis to increase body temperature
  - Can raise body temperature by 0.5°C/hour
  - Patient shivering mechanism must be intact to be effective
- ***Active external rewarming*** (warm blankets, heating pads, warm forced air)
  - Can raise body temperature by 1-2.5°C/hour

Kaur G et al. Hemodial Int. 2017 Oct;21 Suppl 2:S57-S61.

USMP/MG120/19-0013 05/19

Baxter

Recommendations

Patient Temperature Management Recommendations

Be Aware That Hypothermia Is a Common Complication of CRRT

- CRRT-induced hypothermia has been shown to occur in approximately 50% of patients
- Unintentional hypothermia may increase patient morbidity and mortality

Monitor Patient Body Temperature

- Temperature should be monitored at least hourly; patients with a temperature < 36°C should have temperatures monitored continuously

Use Integrated Blood Warmer

- Unwanted hypothermia may be mitigated by using CRRT devices equipped with an integrated blood warmer

Provide Additional External Heating

- Provision of active external heating (heating blankets, warming devices) is recommended

References

References

Akhoundi A, Singh B, Vela M, Chaudhary S, Monaghan M, Wilson GA, Dillon JJ, Cartin-Ceba R, Lieske JC, Gajic O, Kashani K. Incidence of Adverse Events during Continuous Renal Replacement Therapy. Blood Purif. 2015;39(4):333-9.

Badjatia N, Strongilis E, Gordon E, Prescutti M, Fernandez L, Fernandez A, Buitrago M, Schmidt JM, Ostapkovich ND, Mayer SA. Metabolic impact of shivering during therapeutic temperature modulation: the Bedside Shivering Assessment Scale. Stroke. 2008 Dec;39(12):3242-7.

Farley A, McLafferty E. Nursing management of the patient with hypothermia. Nurs Stand. 2008 Jan 2-8;22(17):43-6.

Jones S. Heat loss and continuous renal replacement therapy. AACN Clin Issues. 2004 Apr-Jun;15(2):223-30.

Kaur G, Banoth P, Yerram P, Misra M. A case of hypothermia on CRRT. Hemodial Int. 2017 Oct;21 Suppl 2:S57-S61.

Kiekkas P, Fligou F, Igoumenidis M, Stefanopoulos N, Konstantinou E, Karamouzos V, Aretha D. Inadvertent hypothermia and mortality in critically ill adults: Systematic review and meta-analysis. Aust Crit Care. 2018 Jan;31(1):12-22.

Kurz A. Physiology of thermoregulation. Best Pract Res Clin Anaesthesiol. 2008 Dec;22(4):627-44.

NHS England. Patient Safety Alert. Risk of hypothermia for patients on continuous renal replacement therapy. February 6 2014. https://improvement.nhs.uk/documents/976/hypothermia.pdf

Ricci Z, Romagnoli S. Technical Complications of Continuous Renal Replacement Therapy. Contrib Nephrol. 2018;194:99-108.

Rickard CM, Couchman BA, Hughes M, McGrail MR. Preventing hypothermia during continuous veno-venous haemodiafiltration: a randomized controlled trial. J Adv Nurs. 2004 Aug;47(4):393-400

Prismaflo IIS System Specification Sheet. 306100438_1 c 2013.07. Gambro Lundia AB.

Prismaflo IIS Quick User Guide. USMP/MG142/16-0002 1000 02/16.

Sessler DI. Complications and treatment of mild hypothermia. Anesthesiology. 2001 Aug;95(2):531-43.

Yagi N, Leblanc M, Sakai K, Wright EJ, Paganini EP. Cooling effect of continuous renal replacement therapy in critically ill patients. Am J Kidney Dis. 1998 Dec;32(6):1023-30

Baxter

Thank You

USMP/MG120/19-0013 05/19