

# The introduction of continuous venovenous haemodialysis with citrate anticoagulation to an ICU using a nurse-led protocol

Helen Dickie

Renal Sister, Critical Care Unit

Guy's and St.Thomas' NHS Foundation Trust

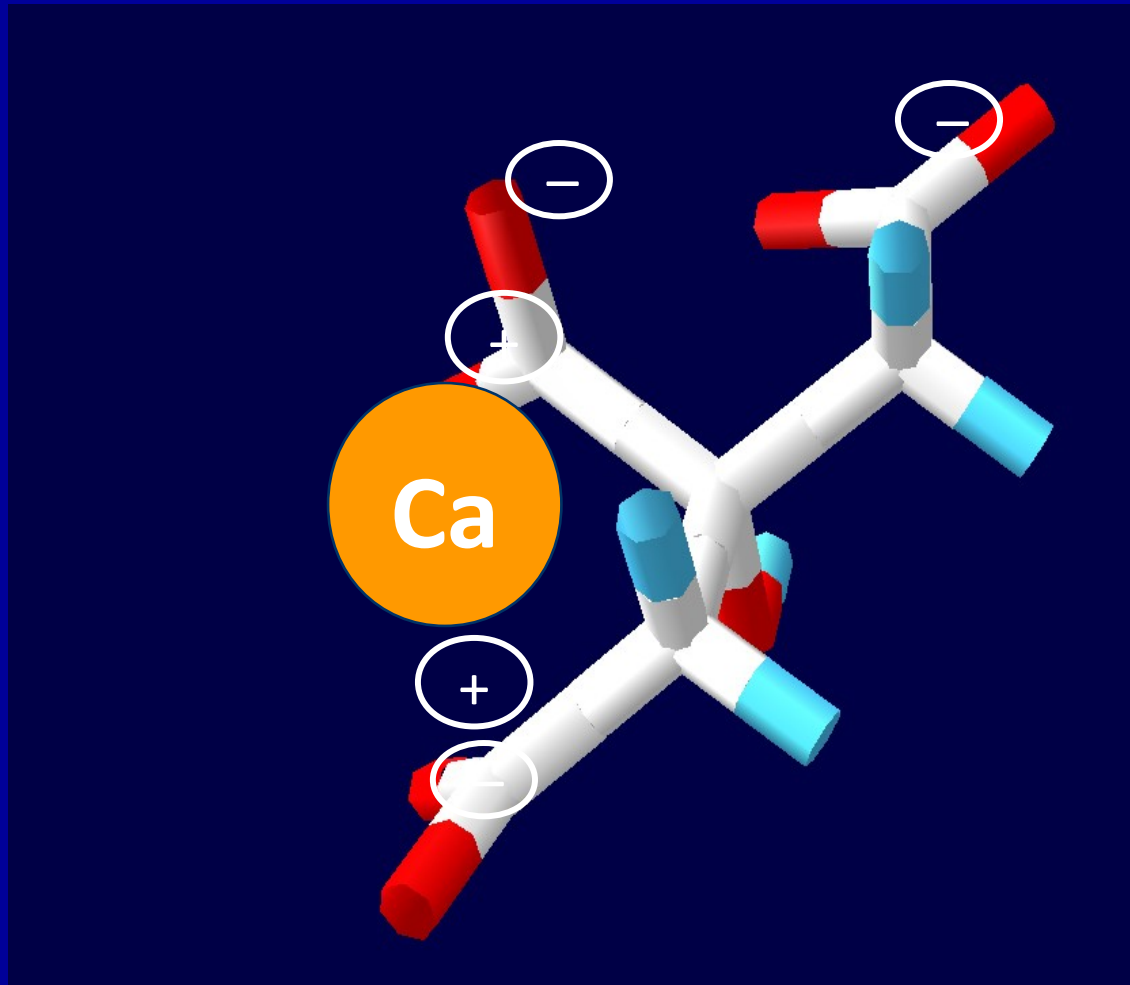
London

# Anticoagulation options for RRT

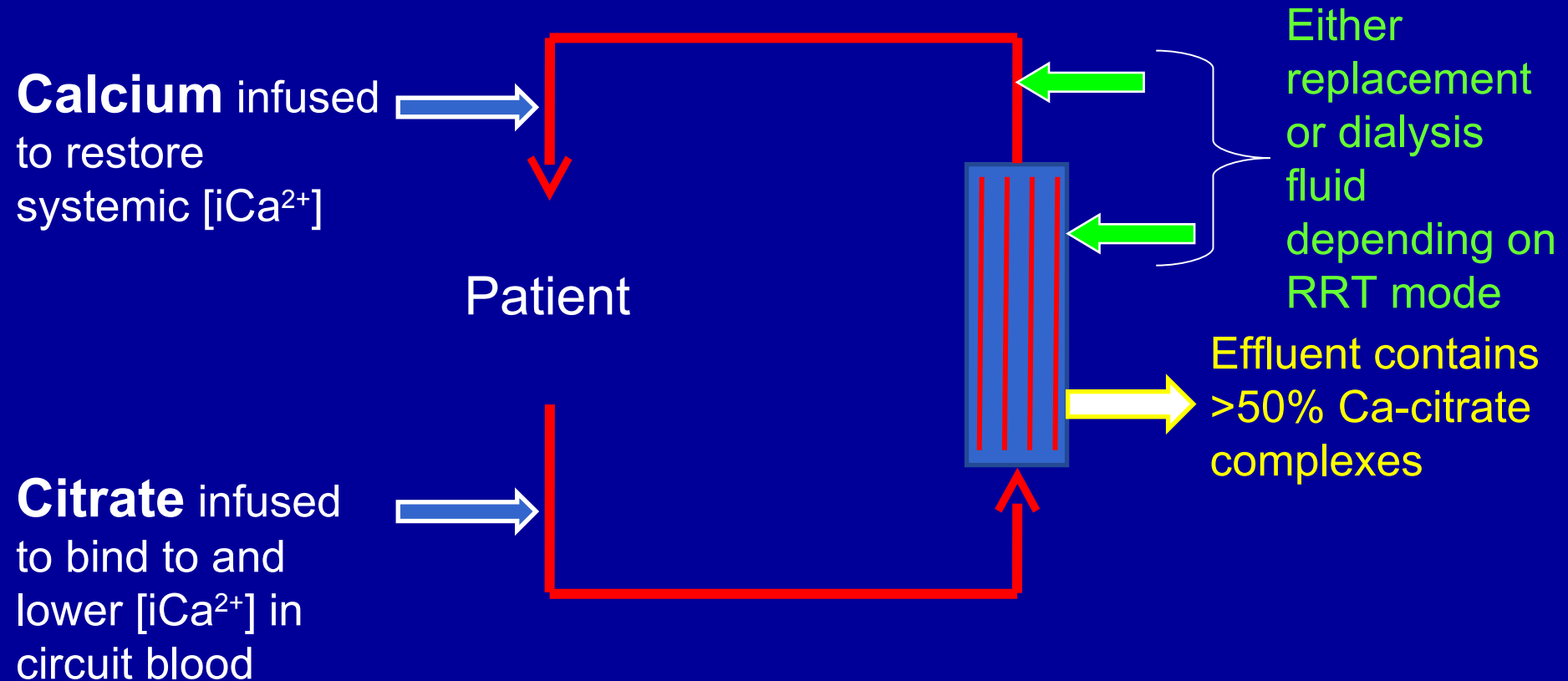
- Unfractionated heparin
- Epoprostenol ( Prostacyclin / Flolan®)
- No anticoagulant
- **Citrate**



# Citrate binds and inactivates $\text{Ca}^{2+}$ ions



# Citrate anticoagulation circuit



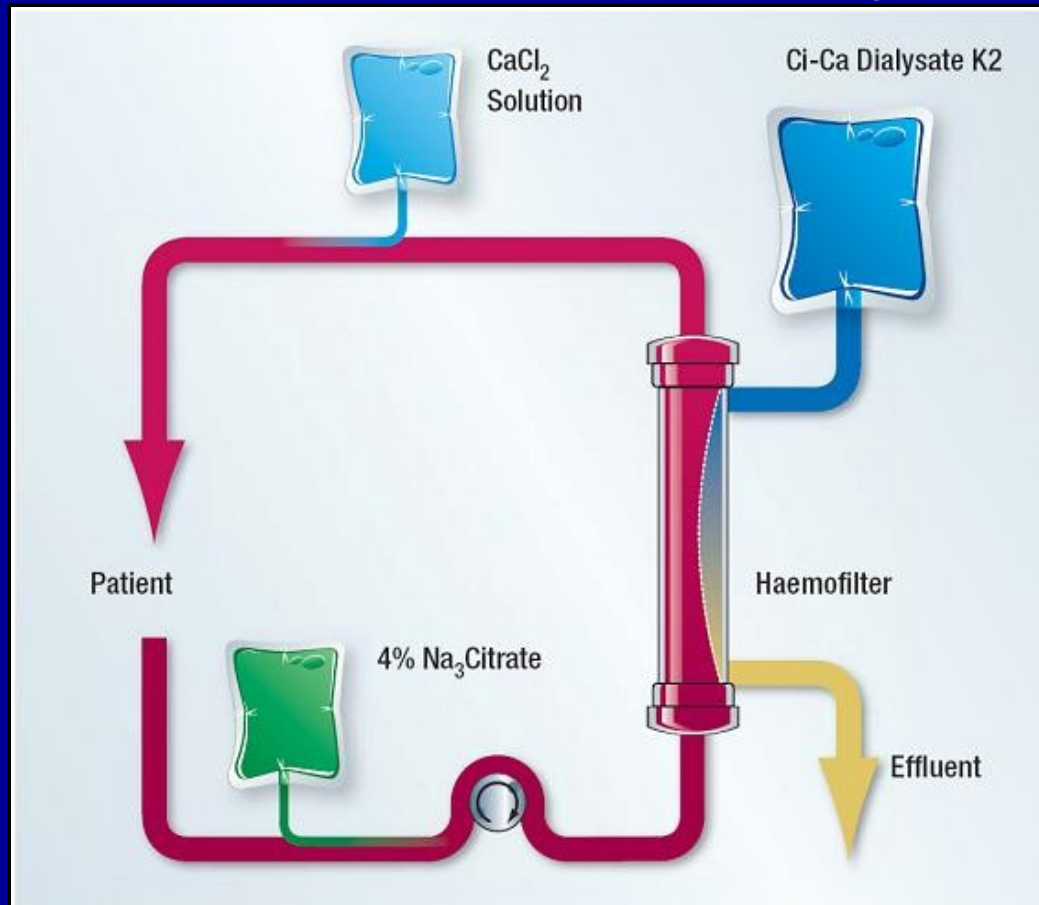
# Possible complications of using citrate

- Hypo / hypercalcaemia      ↓  $\text{Ca}^{2+}$  ↑
- Acid-base imbalance      ↓ Bicarbonate ↑
- Hyponatraemia      ↑  $\text{Na}^+$
- Hypomagnesaemia      ↓  $\text{Mg}^{2+}$

# Citrate anticoagulation for CVVHD

- Morgera et al – Charité Mitte Hospital Berlin

[Morgera et al (2004, 2005, 2009)]



# Fluids required

## Ci-Ca Dialysate K2

Na	133 mmol/L
K	2 mmol/L
Ca	-
Mg	0.75 mmol/L
Cl	116 mmol/L
HCO <sub>3</sub>	20 mmol/L
Glucose	1 g/L



## Tri-Sodium Citrate

136mmol/L (4%)

## Calcium Chloride

100mmol/L

- Na and HCO<sub>3</sub> reduced, in order to compensate for the systemic infusion of Na<sub>3</sub>Citrate
- Calcium-free, to avoid increased citrate requirement  
=> Ca-substitution mandatory

# 'Ci-Ca CVVHD' - multiFiltrate



## Fresenius multiFiltrate CRRT machine with Ci-Ca module

- adapted machine with integrated citrate and calcium pumps controlled by the software
- designed to deliver the Berlin CVVHD protocol
- RRT mode has to be CVVHD as
  1. protocol developed in this mode
  2. fluid used is licensed for dialysis only

# How to manage citrate anticoagulation

At least every 6h :

Check post-filter  $[iCa^{2+}]$

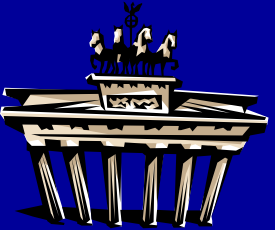
- Adjust citrate rate to keep it in 0.25-0.34 mmol/L range

Check systemic pH, BE and  $[iCa^{2+}]$

- Adjust calcium rate to keep syst  $[iCa^{2+}]$  in 1.12-1.20 mmol/L range.

- Monitor increased calcium requirement and check Total Ca if possibility that citrate is accumulating
- Monitor metabolic acid-base balance and consider adjusting blood flow or dialysate rate if unsatisfactory

# Who should manage the process?



**Berlin ICUs**— small group of nephrologists and a few dialysis nurses who were very familiar with using citrate (ICU nurses not really involved)



## GSTT ICU

- large unit with large number of junior doctors who stay 6m max.
- many nurses who are already expert in running CVVH/HDF
- renal specialist nurse in post to support the process

# Preparing to launch citrate

1. Proposal to the Trust D & T Committee - October 2007
  2. Short daytime trials on 10 patients - Nov 07 to Jan 08
  3. Visit of the Berlin ICU - November 2007
  4. Write the bedside handbook - February 2008
  5. Start training nurses - March 2008
  6. CaCl<sub>2</sub> solution and filters available - May 2008
- ❖ **First patient put on citrate CVVHD on continuous basis - May 2008**

# Initial choice of patients for citrate

- If heparin contra-indicated
- Priority if bleeding and/or poor circuit life
- Sometimes used citrate on other patients just to give trained nurses practical experience
- Use limited by availability of citrate-trained nurses

# Monitoring

- V.close monitoring and support
- Handbook modified
- Data collected on circuit life

# 9 month review – (1)

- Only a few patients showed signs of citrate intolerance
- Clearance generally satisfactory
- Significant improvement in circuit life in citrate circuits
- No significant adverse incidents

# 9 month review – (2)

## Cost implications

### Cost of fluids/anticoagulant for 24h treatment at 2L/h

Citrate / CaCl<sub>2</sub> / Ci-Ca Dialysate = £171

MultiBic / Epoprostenol = £153

MultiBic / Heparin = £78



- Increased fluid/anticoagulant costs may be offset by reduced circuit usage
- Also possibly by reduced blood and blood product usage

# 9 month review – (3)

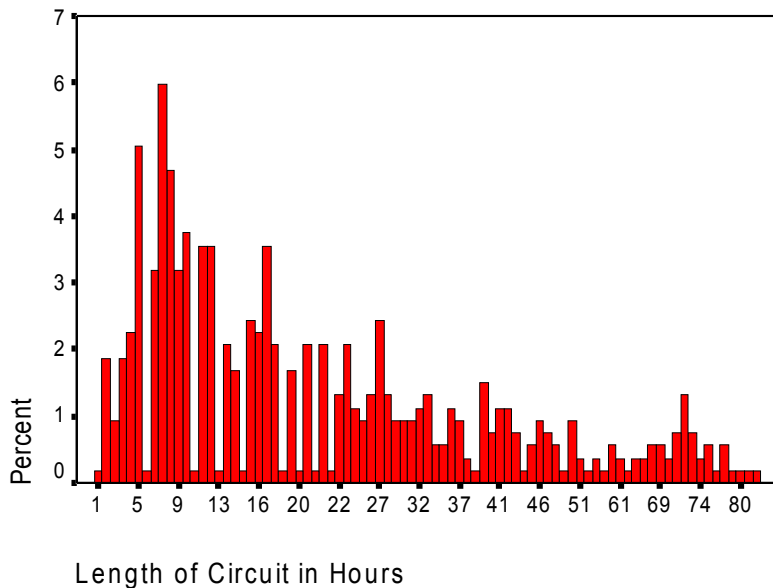
## DECISIONS :

- Extend use of citrate to include
  - patients who would otherwise be given epoprostenol
  - patients on heparin who were using 2 or more circuits/day
- Let citrate circuits run to maximum of 120h rather than 72h

# How long the circuits lasted

Non Citrate: Circuit Life Distribution

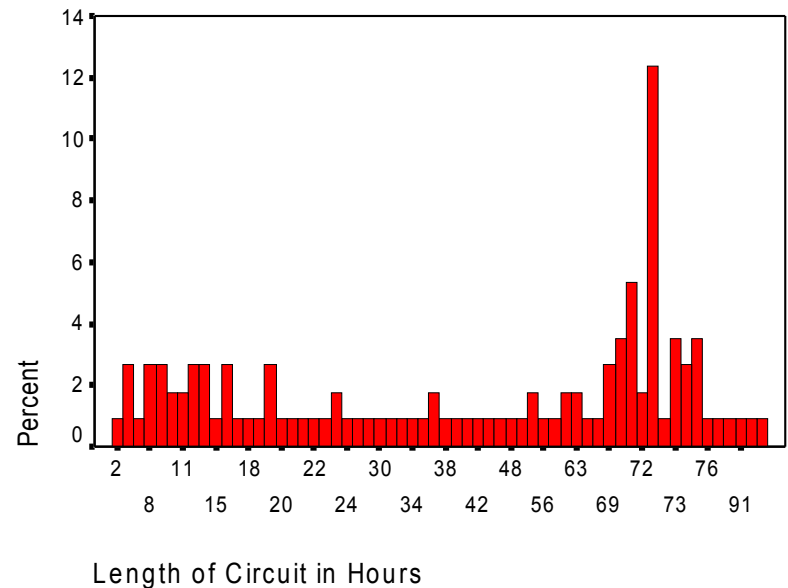
Clotted and 72 Hour Circuits



**Non Citrate Median = 17 Hours**  
**n = 534**

Citrate: Circuit Life Distribution

Clotted and Maximum Circuit Life



**Citrate Median = 51 Hours**  
**n = 113**

May 2009 data

# Staff feedback (1)



- 65 nurses surveyed, 45 responses (69%)
- All had >2y experience in Critical Care

Citrate shifts worked ?	< 5 shifts	5-20 shifts	> 20 shifts
	11 (24.5%)	16 (35.5%)	18 (40%)

Adequate training?	Yes	45 (100%)	No	0 (0%)
Fairly confident ?	Yes	38(84.5%)	No	6 (13.5%)

Workload ?	More work	Less work	Same
	3 (7%)	23 (51%)	18 (40%)

# Staff feedback (2)

**Medical staff** - not formally surveyed, but generally positive and keen to use citrate when possible

# How to launch citrate anticoagulation (1)

- Invest in specialised RRT machines or use 'home-made' system ?
- Which protocol ? (How workable is it?)
- Are solutions needed available commercially ?

# How to launch citrate anticoagulation (2)

- Have lead nurse(s) for the project especially if bedside citrate management to be nurse-led
- Essential to have at least 1 senior doctor involved in the project
- Make provision for adequate, intensive nurse training and support
- Senior doctors should have some training, -ideally junior doctors too

# Work in progress

- **Training of nurses needed long-term**
- **To enable overall evaluation of citrate vs non-citrate anticoagulation:**
  - Circuit life data for citrate and non-citrate circuits continues to be collected
  - Blood transfusion data being collected
  - Relative expenditure on citrate and non-citrate to be calculated

# Conclusions

- Citrate anticoagulation of RRT circuits using the Berlin protocol seems to offer significant advantages in terms of circuit life
- Feasible for ICU nurses to take on the responsibility of managing the technique
- Time must be invested in quite intensive initial and on-going training and support

# Acknowledgements

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## Contact details

Helen Dickie : [helen.dickie@gstt.nhs.uk](mailto:helen.dickie@gstt.nhs.uk)