ATACCC 2009

St Pete's Beach, Florida

Resuscitation strategies in a model of combined blast injury and haemorrhage

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Background: hypotensive resuscitation

- Partial restoration of blood pressure after haemorrhage prior to definitive haemorrhage control
  - Palpable radial pulse
    - NICE TA74 (2004)
    - Emergency War Surgery 3rd US Revision (2004)
  - Some exceptions e.g. head injury
  - Reduced risk of re-bleeding ('popping clots')
- Underpinning evidence
  - Animal studies e.g. pig aortotomy — Kowalenko *et al* 1992
  - Clinical trial — Bickell *et al* 1994
  - Validated for ***short*** delays before surgery

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Timelines and injuries

- Guideline: maximum 1-2 h to surgical care (UK)
  - Currently met but can be longer
  - 4-5 h (Afghanistan) 2-20 h (OIF) Bilski *et al* 2003; Bohman *et al* 2005
- Explosive injury common Nelson *et al* 2006; Champion *et al* 2009
  - Open environment
    - 2° blast injury most common in survivors
    - 1° blast injury (e.g. lung damage): varying reports
  - Confined space / reflecting surface
    - Enhances shock wave and 1° blast injury
    - 1° blast injury common in severely injured Marti *et al* 2006
  - Explosive injury is usually a ***combined*** trauma

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Effects of blast injury on response to resuscitation: original study

- Physiological study (controlled haemorrhage)
  - Early hypotensive *vs* normotensive resuscitation
- Hypotensive resuscitation
  - Initial response (up to 1h) acceptable
  - Reduced survival time after blast and haemorrhage
  - Associated with poor DO_2 and overwhelming metabolic acidosis
  - Significant physiological deterioration after haemorrhage alone

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Aims

- Assess the effects of novel hybrid resuscitation after haemorrhage ± blast injury in a model of survivable battlefield injury
- Endpoints
  - Survival
  - Physiological deterioration
  - Degree of re-bleeding

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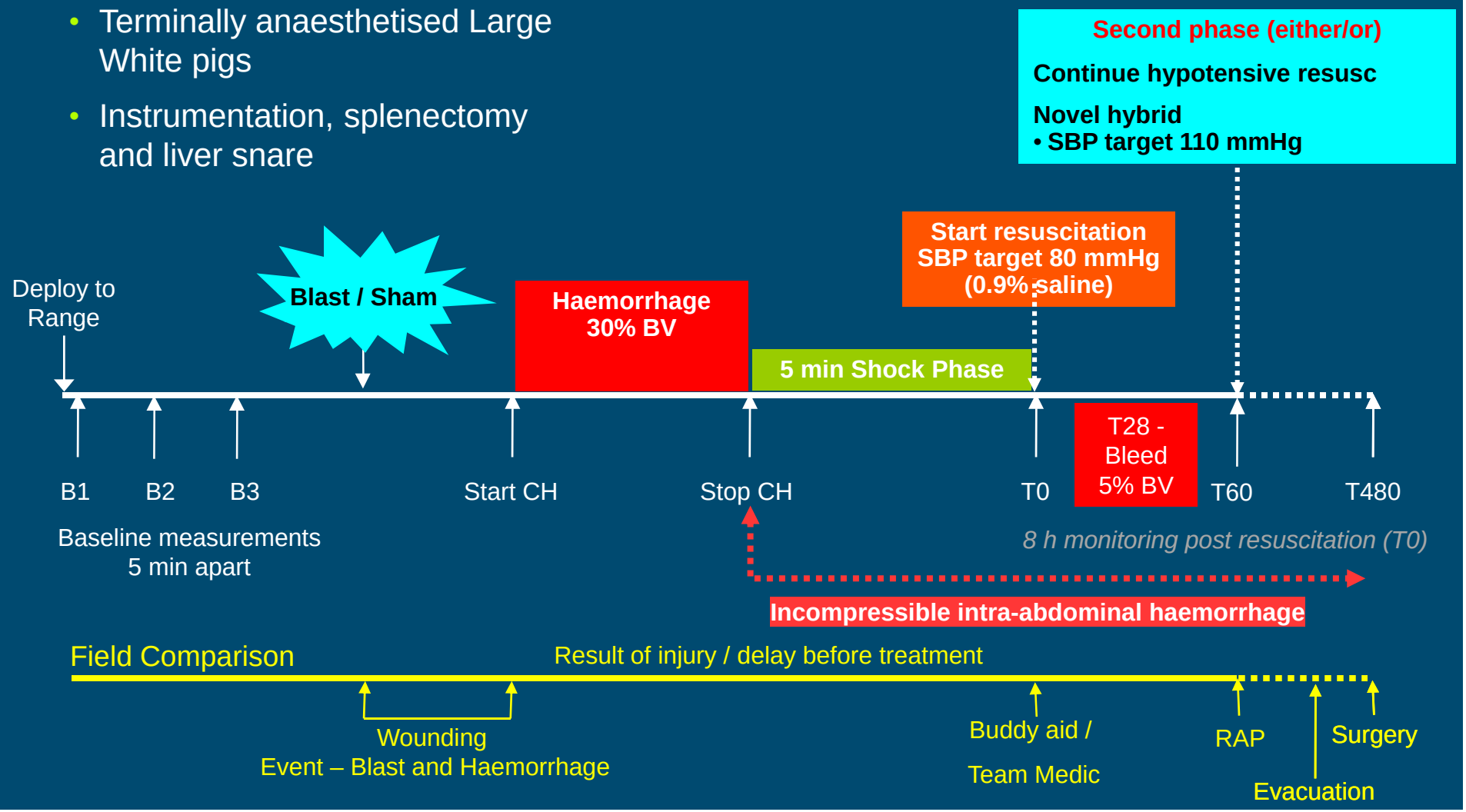
Study protocol – Novel resuscitation

- Terminally anaesthetised Large White pigs
- Instrumentation, splenectomy and liver snare



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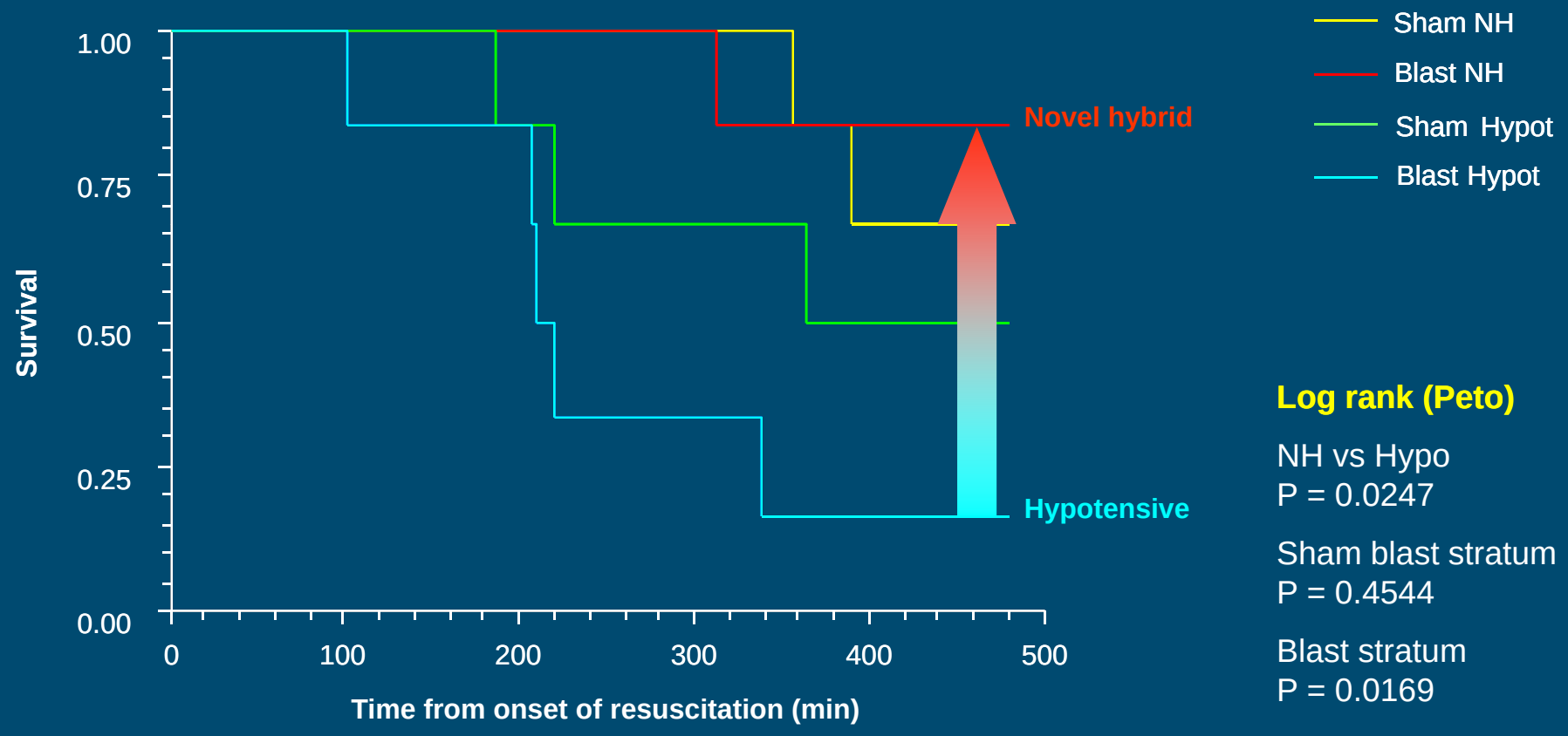
Novel Hybrid resuscitation improves survival time



Log rank (Peto)

NH vs Hypo
P = 0.0247

Sham blast stratum
P = 0.4544

Blast stratum
P = 0.0169

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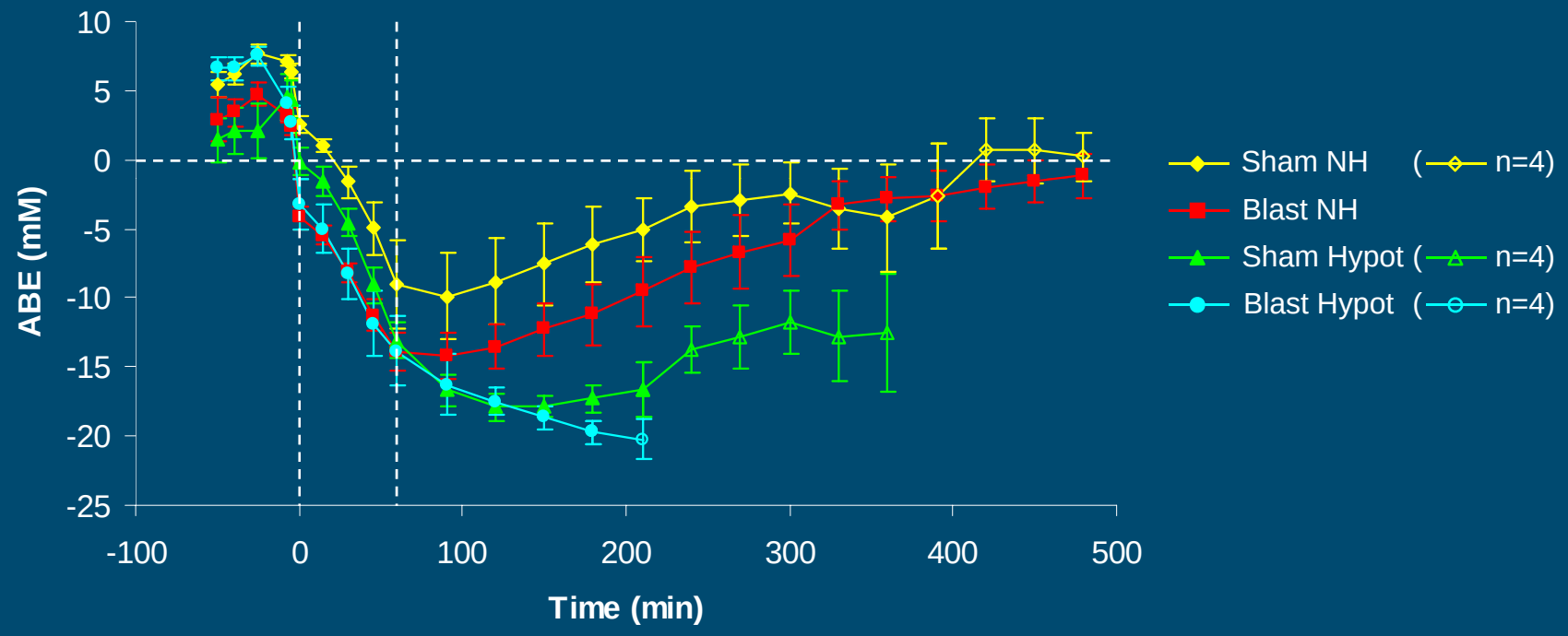
Novel Hybrid resuscitation improves physiological state



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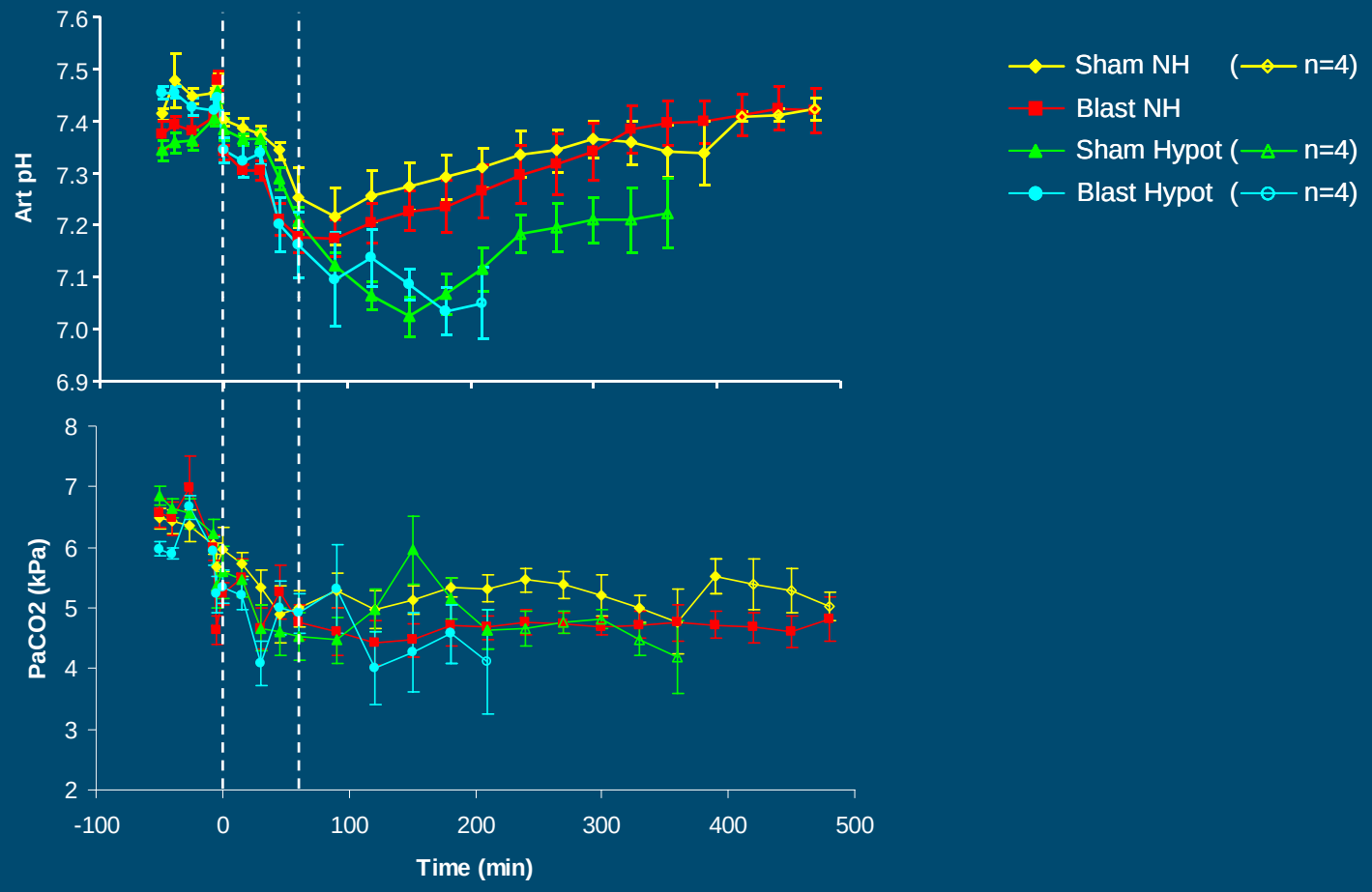
Profound metabolic acidosis with hypotensive resuscitation



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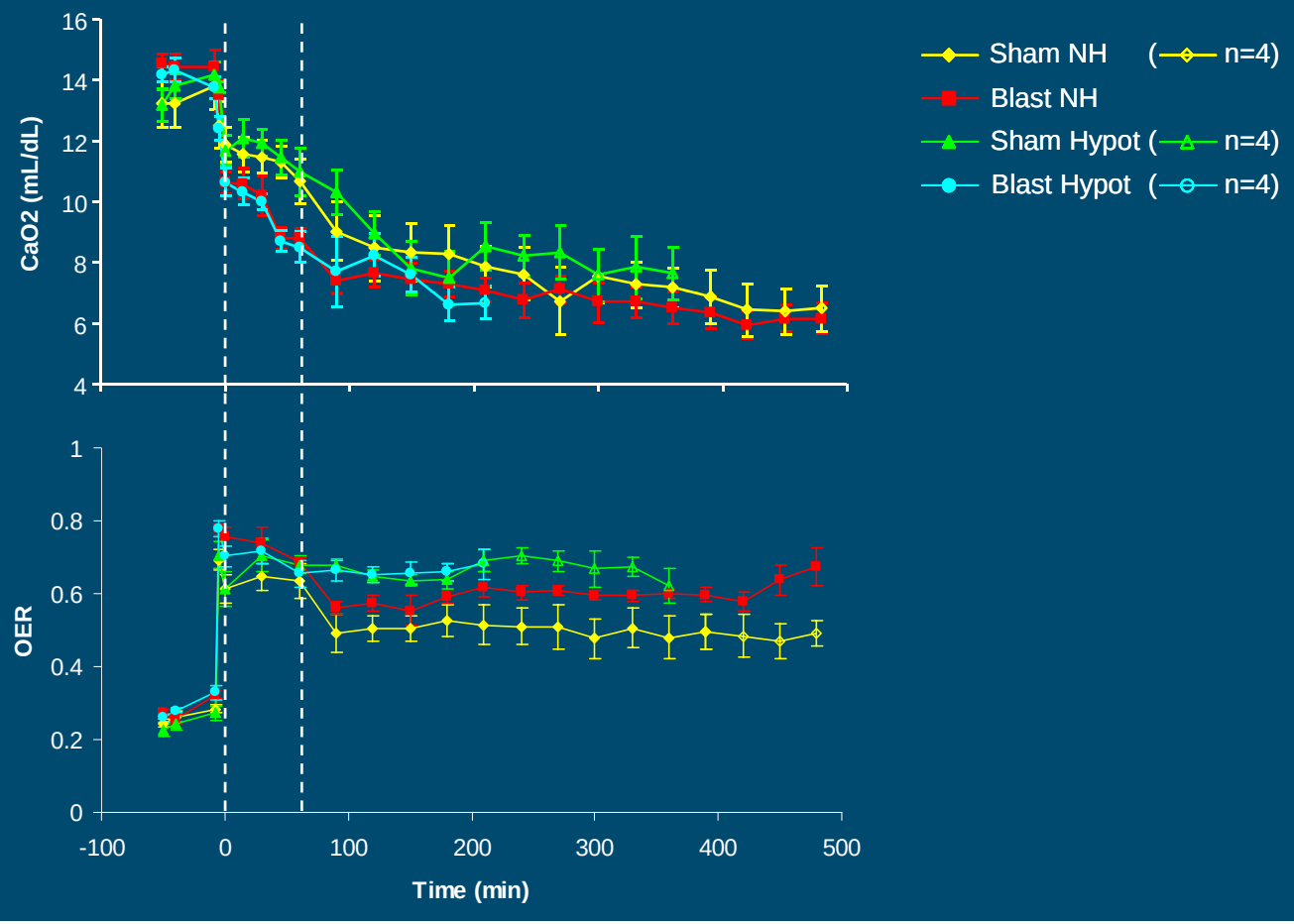
NH does not reduce CaO_2 but does allow a fall in OER



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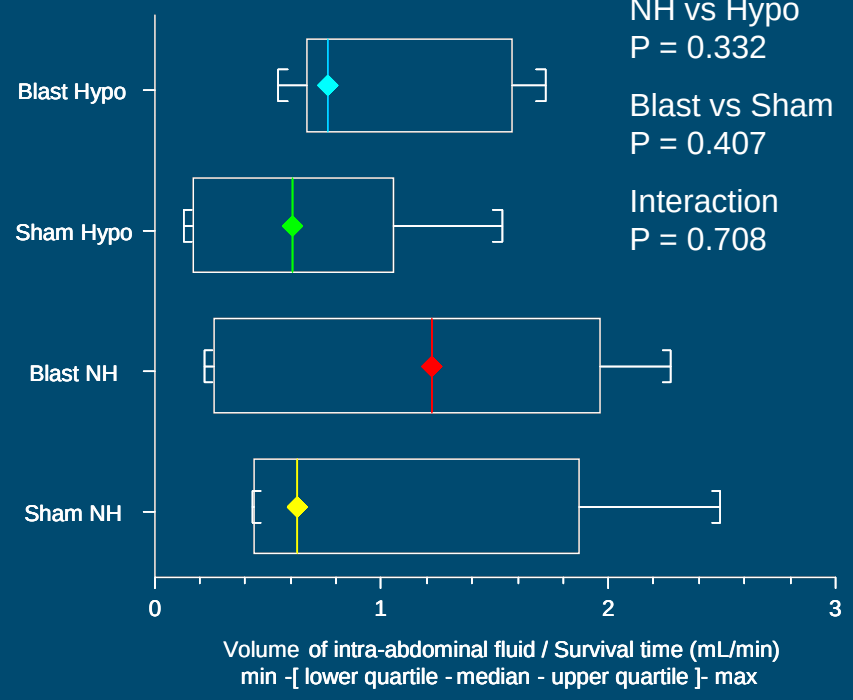
No evidence of increased bleeding with Novel Hybrid



2 Way ANOVA

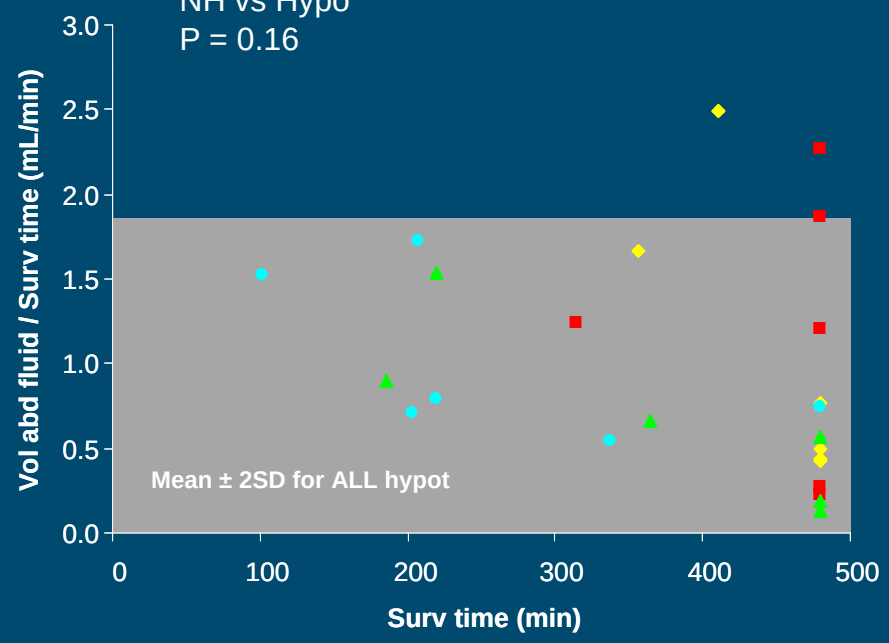
NH vs Hypo
P = 0.332

Blast vs Sham
P = 0.407

Interaction
P = 0.708

Unpaired t-test
ONE TAILED TEST

NH vs Hypo
P = 0.16



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Summary

- Novel hybrid resuscitation leads to improved
  - Survival after combined blast injury and haemorrhage
  - Physiological state after haemorrhage, even in the absence of blast injury
- The improvement appears to be due to better oxygen delivery, allowing a reduction in OER
- There is no evidence of increased bleeding with novel hybrid resuscitation
  - Normotensive phase initiated after clot has developed?

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Conclusions

- Novel hybrid is superior to hypotensive for prolonged resuscitation after blast injury and haemorrhage
- Novel hybrid resuscitation is advocated as an emergency measure when delayed evacuation is enforced

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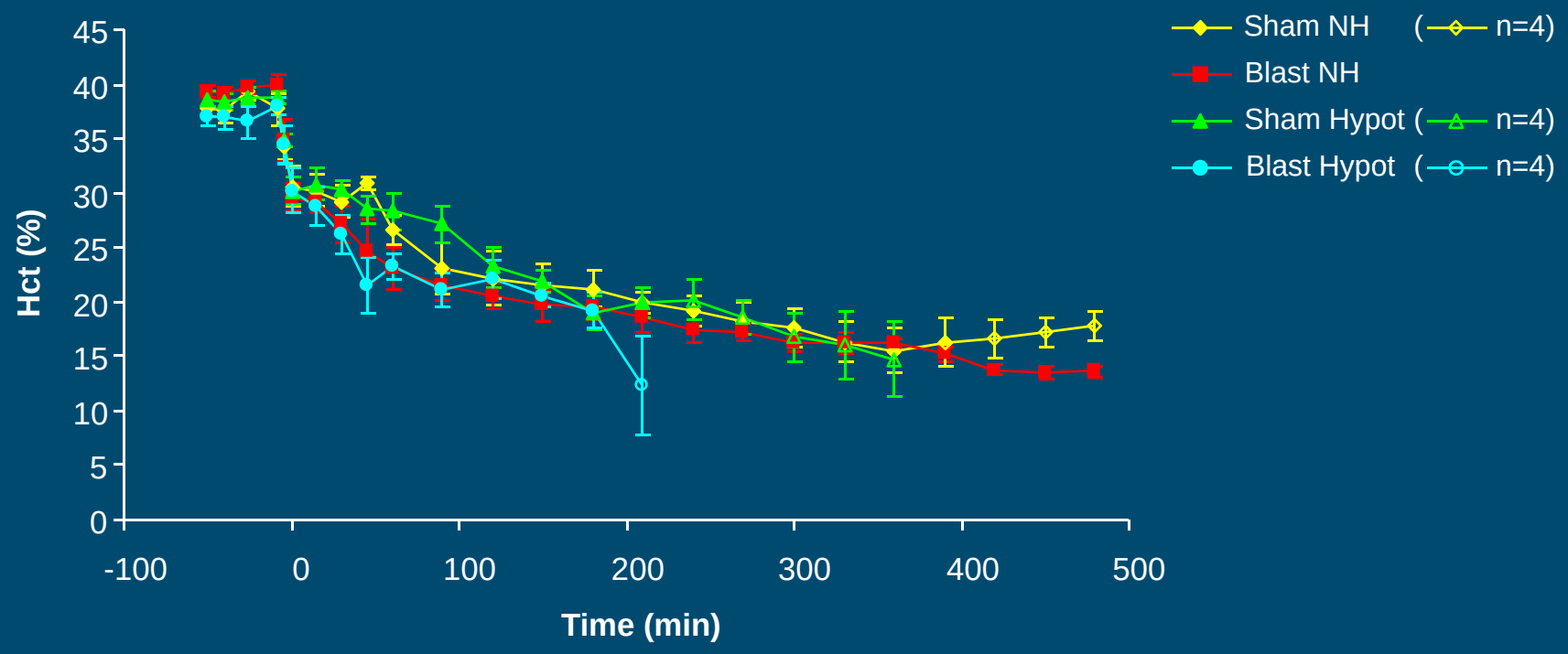
No evidence of dramatically increased haemodilution with NH



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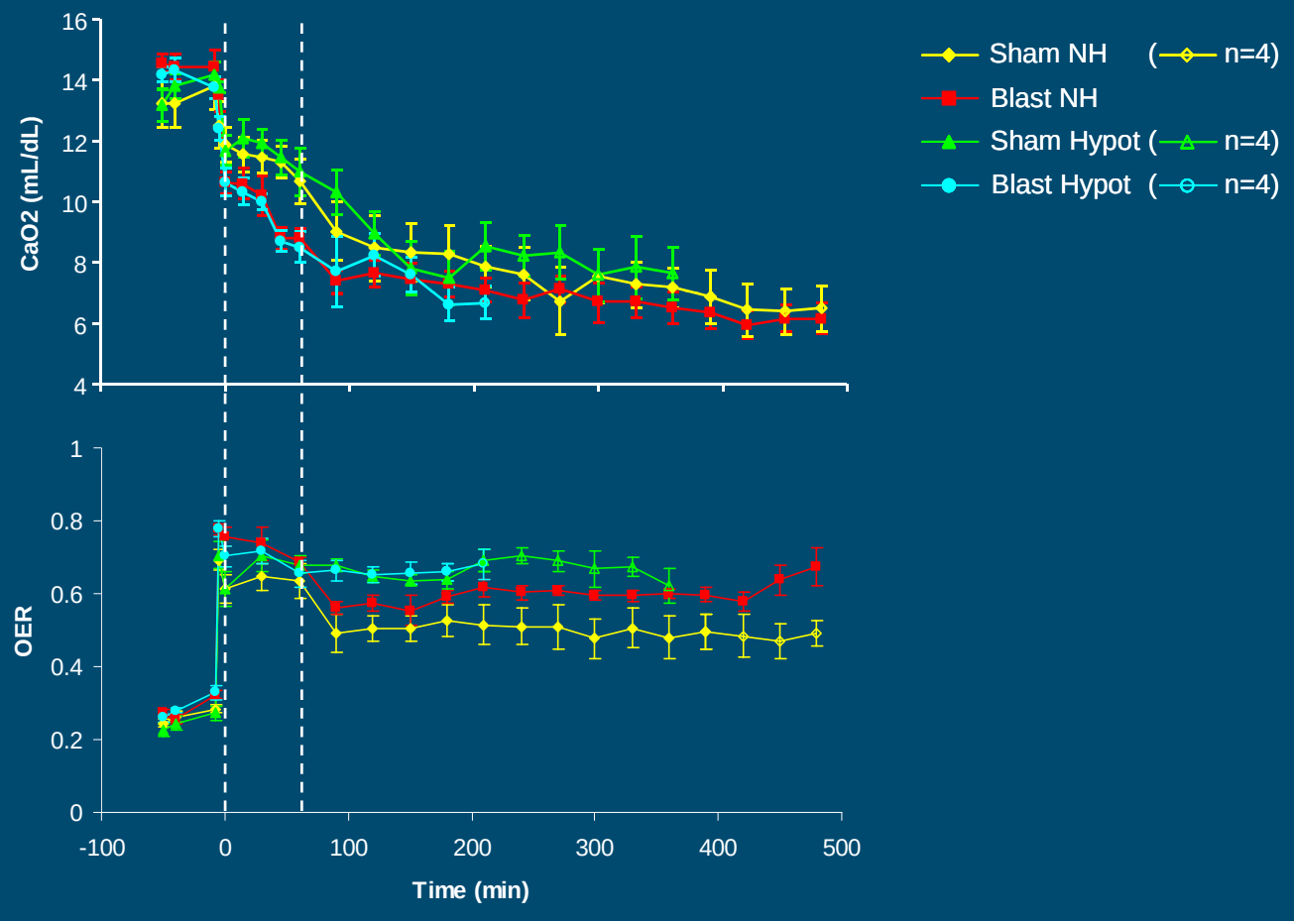

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