# Current trends in fluid management


Folke Sjöberg,

Professor, M.D., Director the Burn Center,
Linköping University Hospital,
Linköping,
Sweden


Care of Burns
In Scotland

# Parkland Formula
# 2-4 ml/kg/TBSA%

**Baxter CR. Fluid volume and electrolyte changes of the early postburn period. Clin Plast Surg. 1974; 1(4): 693-703.**

# Key issues

1. European view?
2. Fluid creep?
   a) Invasive monitoring and fluid treatment (Holm et al.)
   b) Speed of fluid administration (Csontos et al.; Bak et al.)
   c) Ventilation effects (Mackie et al.)
3. Physiologic findings
   a) Neg. Imbebition pressure (Lund and Reed)
   b) Permeability (Vlachou et al.)
4. Starches/hyperoncotic (Bechir et al.) and albumin
5. Situation in skin – ischemia or inflammatory induced cellular dysfunction
6. Conclusion Parkland – close surveillance

BURNS 36 (2010) 176–182

ELSEVIER

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

BURNS

**Burn resuscitation: The results of the ISBI/ABA survey**☆

*David G. Greenhalgh* [a,b,*]

[a] Shriners Hospitals for Children Northern California, 2425 Stockton Blvd., Sacramento, CA 95817, United States
[b] Department of Surgery, University of California, Davis, United States

# European view?

BURNS 36 (2010) 176–182

**Table 1 – Preferred resuscitation formulas.**

Parkland – 70 (69.3%)
  Modified for 7
Colloid – 12 (11.9%)
Galveston – 9 (8.9%)
Brooke – 7 (6.9%)
Warden – 6 (5.9%)
Consensus – 5 (5%)
Slater – 2 (2%)
Hypertonic – 1 (1%)

**Table 2 – The various fluids utilized for burn resuscitation.**

Lactated Ringers – 92 (91.1%)
Albumin solution – 21 (20.8%)
Fresh frozen plasma – 14 (13.9%)
LR/$NaHCO_3$ – 13 (12.9%)
Normal saline – 5 (5%)
Hartmann's solution - 5
Hespan – 4
Others (tetrastarch, normosol, plasmalyte, Ringers acetate, HTS/dextran/mannitol, Vit C)

BURNS 36 (2010) 176–182

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

ELSEVIER

BURNS

# Burn resuscitation: The results of the ISBI/ABA survey☆

David G. Greenhalgh[a,b,*]

[a] Shriners Hospitals for Children Northern California, 2425 Stockton Blvd., Sacramento, CA 95817, United States
[b] Department of Surgery, University of California, Davis, United States

BURNS 36 (2010) 176–182

**Table 3 – Methods used to adjust fluids during burn shock resuscitation.**

Urine output – 94.9%
Other indicators – 22.7%
- CVP – 9
- Pa catheter – 8
- Base deficit – 7
- Lactate – 5
- LiDCO – 5
- PiCCO – 3
- Clinical – 3
- Hematocrit – 1

# Present situation?!

## “Fluid creep”

Table 2. Review of modern reports of fluid creep

| Reference | No. of Patients Who Exceeded Parkland Requirements | Resuscitation Received, ml/kg/%TBSA |
|---|---|---|
| Kaups et al (1998)[6] | 83/83 (100%) | NA |
| Engrav et al (2000)[11] | 29/50 (58%) | 5.2 ± 2.3 (no range given) |
| Ivy et al (2000)[7] | 98/109 (90%) | 9.36 (2.2–38.6) |
| Cartotto et al (2002)[10] | 26/31 (84%) | 6.7 ± 2.8 |
| Cancio et al (2004)[59] | 56/89 (63%) | 6.1 ± 0.22 (no range given) |
| Friedrich et al (2004)[8], Sullivan et al (2004)[9] | NA | 3.6 ± 1.1 (1970s) vs. 8.0 ± 2.5 (2000) |

ORIGINAL ARTICLES

The Phenomenon of “Fluid Creep” in Acute Burn Resuscitation

Jeffrey R. Saffle, MD, FACS

JBCR 2007

ELSEVIER
Burns 30 (2004) 798–807
BURNS
www.elsevier.com/locate/burns

# A clinical randomized study on the effects of invasive monitoring on burn shock resuscitation

C. Holm[a,*], M. Mayr[a], J. Tegeler[a], F. Hörbrand[a], G. Henckel von Donnersmarck[a],

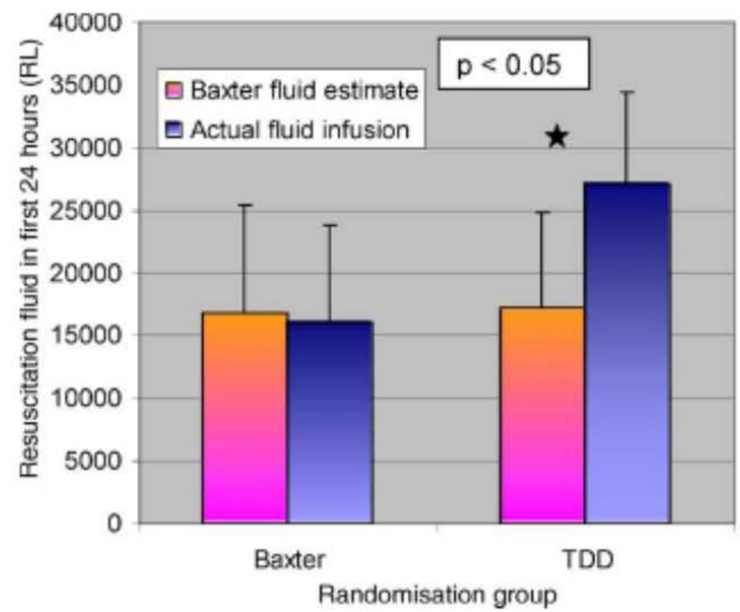
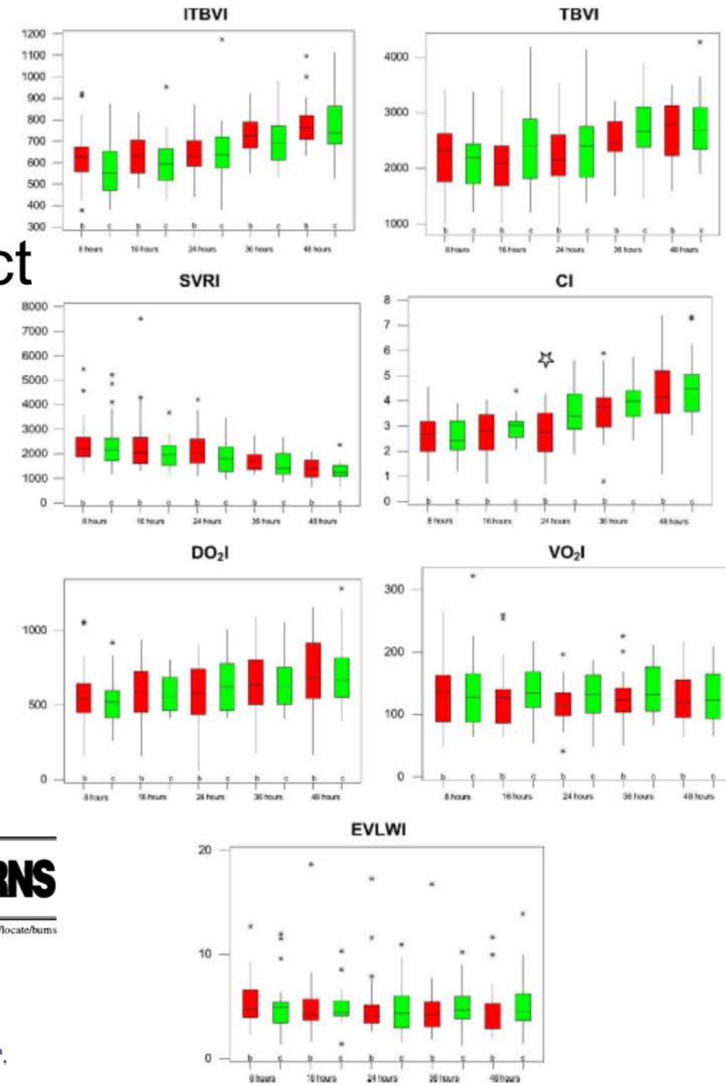



Fig. 1. Actual volume received and Baxter fluid estimate (lactated Ringer's) for the first 24 h following burn. Statistical significance between fluid estimate and actual fluid infusion was found in the TDD group and is indicated by asterisk ($P < 0.05$).

# More fluid – little effect




VIER
Burns 30 (2004) 798–807
BURNS
www.elsevier.com/locate/burns

A clinical randomized study on the effects of invasive monitoring on burn shock resuscitation

C. Holm[a,*], M. Mayr[a], J. Tegeler[a], F. Hörbrand[a], G. Henckel von Donnersmarck[a],

Burns 30 (2004) 798–807

BURNS

www.elsevier.com/locate/burns

# A clinical randomized study on the effects of invasive monitoring on burn shock resuscitation

Table 1
Standard haemodynamic, perfusion and rheological data (mean values ± S.D.)

| | Time | BAXTER (mean values) | TDD (mean values) | Significance |
|---|---|---|---|---|
| MAP (mm Hg) | $T_1$ | 78 (±13.7) | 74 (±10.7) | NS |
| | $T_2$ | 76 (±9.7) | 77 (±13.1) | NS |
| | $T_3$ | 76 (±14.3) | 84 (±13.2) | NS |
| | $T_4$ | 86 (±11.2) | 84 (±12.2) | NS |
| | $T_5$ | 81 (±11.8) | 81 (±11.2) | NS |
| HR (beats $min^{-1}$) | $T_1$ | 87 (±21.9) | 94 (±19.7) | NS |
| | $T_2$ | 100 (±23.9) | 99 (±20.6) | NS |
| | $T_3$ | 99 (±26.5) | 105 (±18.0) | NS |
| | $T_4$ | 94 (±19.9) | 99 (±15.1) | NS |
| | $T_5$ | 103 (±24.1) | 102 (±16.6) | NS |
| CVP (mm $H_2O$) | $T_1$ | 6 (±2.9) | 6 (±3.3) | NS |
| | $T_2$ | 7 (±3.7) | 7 (±2.8) | NS |
| | $T_3$ | 7 (±3.0) | 10 (±5.6) | 0.005* |
| | $T_4$ | 8 (±4.6) | 12 (±6.1) | 0.038* |
| | $T_5$ | 9 (±3.8) | 12 (±6.5) | 0.027* |
| Diuresis (ml $min^{-1}$) | $T_1$ | 167 (±132.0) | 203 (±176.4) | NS |
| | $T_2$ | 157 (±120.2) | 242 (±146.6) | 0.031* |
| | $T_3$ | 123 (±92.8) | 205 (±127.2) | 0.012* |
| | $T_4$ | 163 (±77.9) | 266 (±128.0) | 0.001* |
| | $T_5$ | 186 (±79.3) | 287 (±160.3) | 0.008* |
| Hk (mg/dl) | $T_1$ | 42.7 (±5.5) | 42.4 (±6.7) | NS |
| | $T_2$ | 45.0 (±6.6) | 41.0 (±6.7) | 0.037* |
| | $T_3$ | 43.1 (±6.7) | 38.9 (±8.5) | NS |
| | $T_4$ | 37.9 (±7.2) | 34.3 (±5.5) | NS |
| | $T_5$ | 35.3 (±4.9) | 33.1 (±4.9) | NS |

10

26

Acta Anaesthesiol Scand 2008; 52: 742–749

ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2008.01658.x

# Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation

C. Csontos[1], V. Foldi[1], T. Fischer[2] and L. Bogar[1]
[1]Department of Anaesthesia and Intensive Care and [2]Department of Surgery, Faculty of Medicine, University of Pécs, Hungary

Acta Anaesth Scand 2008;52:742-49

**Fluid resuscitation after burn injury**

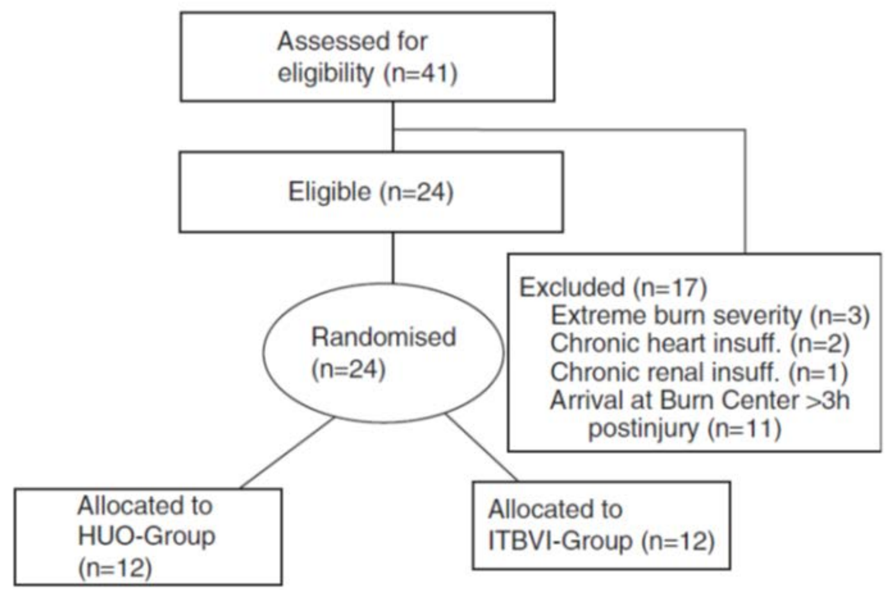



*Fig. 1. Flowchart of the study.*

Csontos, et al., Acta Anaesth Scand 2008;52:742-49

*Table 2*

Summary of measured and calculated parameters of the patients during the study period (72 h).

| Parameter | Group | Day 1 | Day 2 | Day 3 |
|---|---|---|---|---|
| $ScvO_2$ (%) | HUO | 68 (64–71) | 72 (61–77)††† | 76 (71–78) †††,** |
| | ITBVI | 74 (71–78) | 74 (69–79) | 77 (73–79)‡,† |
| | | $P = 0.024$ | NS | NS |
| MODS | HUO | 4.0 (2.0–5.0) | 5.0 (4.3–5.8)† | 5.0 (4.3–6.0)† |
| | ITBVI | 3.5 (3.0–5.0) | 4.0 (3.0–4.3) | 3.0 (3.3–3.8)* |
| | | NS | $P = 0.024$ | $P = 0.014$ |
| ITBVI (ml/m$^2$) | HUO | 723 (590–844) | 802 (701–959)††† | 860 (785–965)†††,* |
| | ITBVI | 851 (753–970) | 873 (817–920) | 970 (903–1020)††,** |
| | | $P = 0.009$ | $P = 0.043$ | $P = 0.003$ |
| CVP (cm$H_2O$) | HUO | 6.0 (4.0–11.5) | 8.0 (4.0–12.0) | 11.5 (5.0–12.8)† |
| | ITBVI | 8.0 (4.8–12.0) | 10.0 (6.8–18.3) | 12.0 (7.0–15.8)† |
| | | NS | NS | NS |
| CI (l/m$^2$) | HUO | 3.0 (2.4–3.5) | 3.9 (3.0–5.0)†† | 3.8 (2.9–4.7)†† |
| | ITBVI | 3.5 (3.3–3.8) | 4.2 (3.4–5.2)† | 4.3 (3.1–5.0)†† |
| | | $P = 0.013$ | NS | NS |
| Serum lactate (mmol/l) | HUO | 2.4 (1.7–3.6) | 2.0 (1.6–3.1)† | 1.7 (1.3–2.8)††,* |
| | ITBVI | 2.3 (1.3–4.7) | 2.2 (1.6–3.2) | 2.0 (1.4–2.3) |
| | | NS | NS | NS |
| $PaO_2/FiO_2$ ratio (kPa) | HUO | 43.7 (32.8–49.6) | 34.5 (29.2–37.5)†† | 32.6 (28.6–34.9)††,* |
| | ITBVI | 44.5 (33.7–55.1) | 29.7 (26.6–32.9)†† | 30.5 (27.2–33.9)†† |
| | | NS | NS | NS |
| EVLWI (ml/kg) | HUO | 6.0 (5.0–7.0) | 7.0 (6.0–9.0) | 7.0 (6.5–7.0) |
| | ITBVI | 6.0 (5.0–7.0) | 6.0 (5.5–7.8) | 6.5 (6.0–7.8) |
| | | NS | NS | NS |
| EVLWI/ITBVI (m$^2$/kg) | HUO | 0.0082 (0.0068–0.0098) | 0.0085 (0.0078–0.0103) | 0.0081 (0.0068–0.0098) |
| | ITBVI | 0.0070 (0.0059–0.0088) | 0.0072 (0.0055–0.0082) | 0.0069 (0.0054–0.0086) |
| | | $P = 0.025$ | $P = 0.008$ | $P = 0.023$ |
| Urine output (ml/kg/h) | HUO | 0.8 (0.6–1.0) | 0.9 (0.8–1.0)† | 0.8 (0.7–1.0)* |
| | ITBVI | 1.1 (0.9–1.4) | 1.0 (0.7–1.1) | 1.0 (0.9–1.2) |
| | | $P = 0.0008$ | NS | $P = 0.0012$ |
| Hemoglobin (g/l) | HUO | 125.0 (110.0–138.8) | 120.0 (102.5–130.0) | 112.3 (101.3–120.3)†††,** |
| | ITBVI | 112.5 (100.3–120.5) | 110.3 (100.3–115.5) | 100.3 (90.5–110.3)†††,** |
| | | $P = 0.002$ | $P = 0.007$ | $P = 0.009$ |

Data are expressed as median and interquartile range. Median values were calculated taking all measurements of all patients of a group on the same day. $ScvO_2$, oxygen saturation of the central venous hemoglobin; MODS, multiple organ dysfunction score; ITBVI, intrathoracic blood volume index; CVP, central venous pressure; CI, cardiac index; EVLWI, extravascular lung water index. Symbols indicate within group differences.

†$P<0.05$, ††$P<0.01$, †††$P<0.001$ comparing to day 1, *$P<0.05$, **$P<0.01$, ***$P<0.001$ comparing to day 2, $P$ values and NS indicate intergroup statistical differences.

# Arguments for a more rapid administration

*Acta Anaesthesiol Scand 2008; **52**: 742–749*



ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2008.01658.x

**Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation**

C. Csontos[1], V. Foldi[1], T. Fischer[2] and L. Bogar[1]
[1]*Department of Anaesthesia and Intensive Care and* [2]*Department of Surgery, Faculty of Medicine, University of Pécs, Hungary*

Significantly more fluid was administered in the ITBVI group than the HUO group on the first day after injury (5.7 ml/BBS/kg, IQR 4.5–6.5; 4.7 ml/BBS/kg, 4.4–5.2, respectively, $P = 0.019$). Moreover, 58% of the extra fluid was administered in the first 8 h, 28% in the second 8 h, and only 14% in the last 8 h.

# Arguments for a more rapid administration

The Journal of TRAUMA® Injury, Infection, and Critical Care

## Hemodynamic Changes During Resuscitation After Burns Using the Parkland Formula

*Zoltan Bak, MD, PhD, Folke Sjöberg, MD, PhD, Oll*
*and Birgitta Janerot-Sjoberg, MD, PhD*

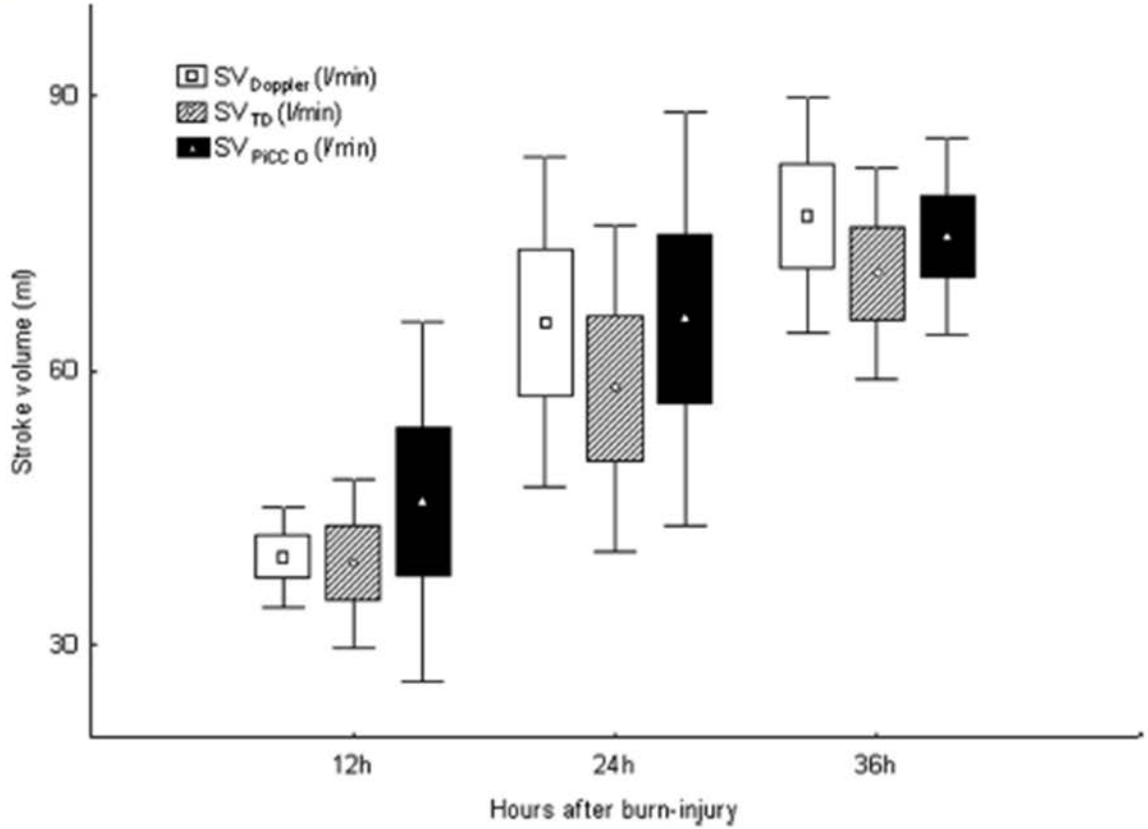



**Fig. 2.** *Box plots of stroke volumes as measured by the three different, simultaneously used, methods. Mean, SE, and 95% confidence interval are shown within each box.*

# Arguments for a more rapid administration

The Journal of TRAUMA® Injury, Infection, and Critical Care

**Hemodynamic Changes During Resuscitation After Burns Using the Parkland Formula**

*Zoltan Bak, MD, PhD, Folke Sjöberg, MD, PhD, O*
*and Birgitta Janerot-Sjoberg, MD, PhD*

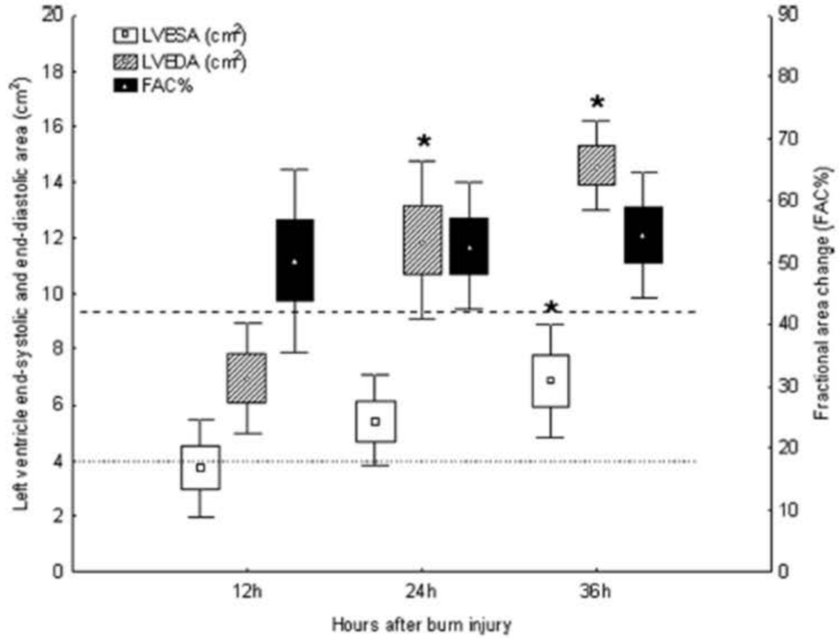



**Fig. 1.** *Left ventricular end-diastolic area (LVEDA), left ventricular end-systolic area (LVESA), together with percentage fractional changes in area (FAC%) at the three time points of measurement. Lower reference limits: LVEDA,* dashed line; *LVESA,* dotted line *(left* y *axis). Mean, SE, and 95% confidence interval are shown within each box. *Significant difference* ($p < 0.05$) *compared with the first measurement.*

The Journal of TRAUMA® Injury, Infection, and Critical Care

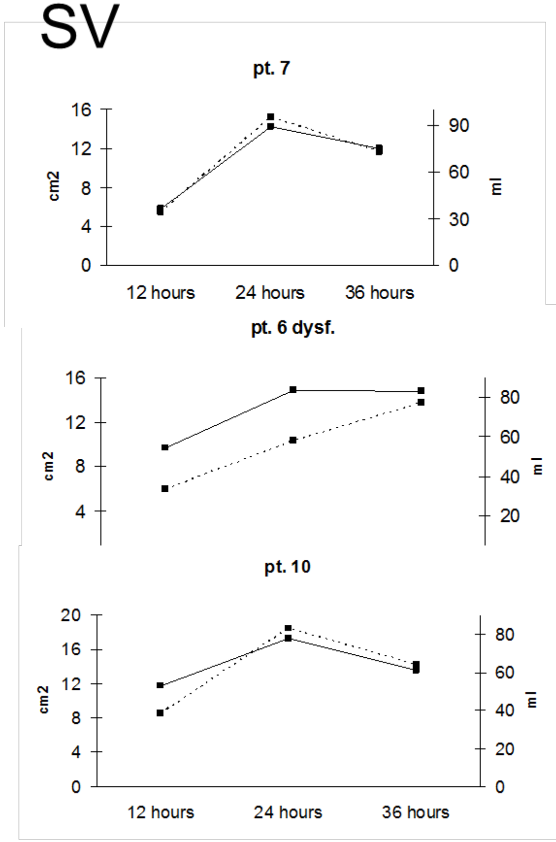
**Hemodynamic Changes During Resuscitation After Burns Using the Parkland Formula**

*Zoltan Bak, MD, PhD, Folke Sjöberg, MD, PhD, Olle Eriksson, PhD, Ingrid Steinvall, MSN, and Birgitta Janerot-Sjoberg, MD, PhD*

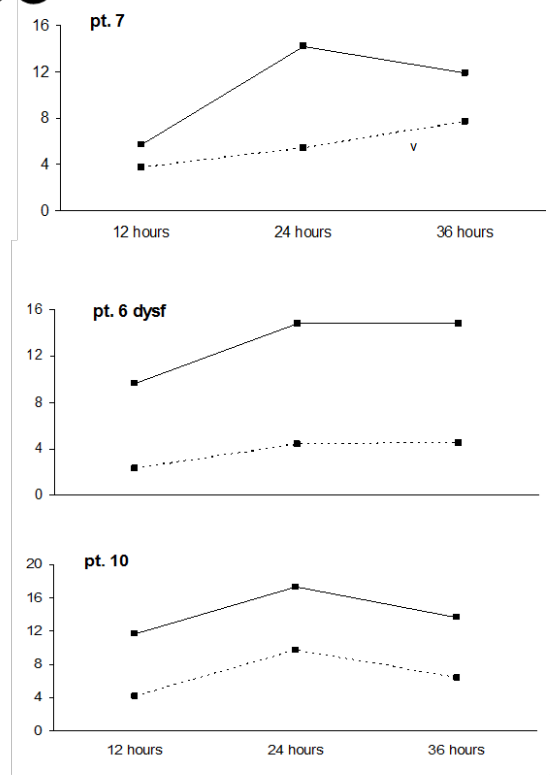
Arguments for a more rapid administration

# SV changes together with preload changes

SV




CO



Critical Care

CRITICAL CARE

This Provisional PDF corresponds to the article as it appeared upon acceptance. Copyedited and fully formatted PDF and full text (HTML) versions will be made available soon.

**A protocol for resuscitation of severe burn patients guided by transpulmonary thermodilution and lactate levels: A 3-year prospective cohort study.**

*Critical Care* 2013, **17**:R176 doi:10.1186/cc12855

Manuel Sanchez-Sanchez (manuelsanchezsa

**Table 2. Hemodynamic, temperature, and blood gas measurements.**

| | **Initial** | **24 h** | **48 h** | **72 h** |
|---|---|---|---|---|
| HR (bpm) | 83±21 | 95±19 | 95±19 | 95±18 |
| Temperature (°C) | 35.5±1.8 | 36.9±1.0 | 36.6±0.9 | 36.6±1.3 |
| MAP (mmHg) | 85±18 | 83±13 | 79±12 | 78±8 |
| PaO2/FiO2 ratio | 338±197 | 294±114 | 269±103 | 292±136 |
| CI (L/min/m$^2$) | 2.68±1.06 | 3.22±1.12 | 3.97±1.12 | 4.43±0.87 |
| SVI (mL/m$^2$) | 33.7±13.9 | 35.1±13.2 | 42.7±12.6 | 47.1±10.7 |
| ITBVI (mL/m$^{2)}$ | 709±254 | 744±276 | 823±230 | 896±214 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

**Conclusions:** Initial hypovolemia may be detected by TPTD monitoring during the early resuscitation phase. This hypovolemia might not be reflected by blood pressure and hourly urine output. An adequate CI and tissue perfusion can be achieved with below-normal levels of preload. Early resuscitation guided by lactate levels and below-normal preload volume targets appears safe and avoids unnecessary fluid input.

# Arguments for a more rapid administration

*Acta Anaesthesiol Scand* 2008; **52**: 725–726

ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2008.01679.x

*Editorial*

## The 'Parkland protocol' for early fluid resuscitation of burns: too little, too much, or . . . even . . . too late . . .?

FOLKE SJÖBERG
*Department of Hand and Plastic Surgery and Intensive Care, Division of Perioperative Medicine and Intensive Care, Berzelius Clinical Research Center, Linköping University Hospital, 581 85 Linköping, Sweden*

ORIGINAL ARTICLE

Mechanical Ventilation and Fluid Retention in Burn Patients

David P. Mackie, MD, Ed J. Spoelder, MD, Roel J. Paauw, MD, Paul Knape, MD, PhD, and Christa Boer, PhD

(*J Trauma*. 2009;67: 1233–1238)

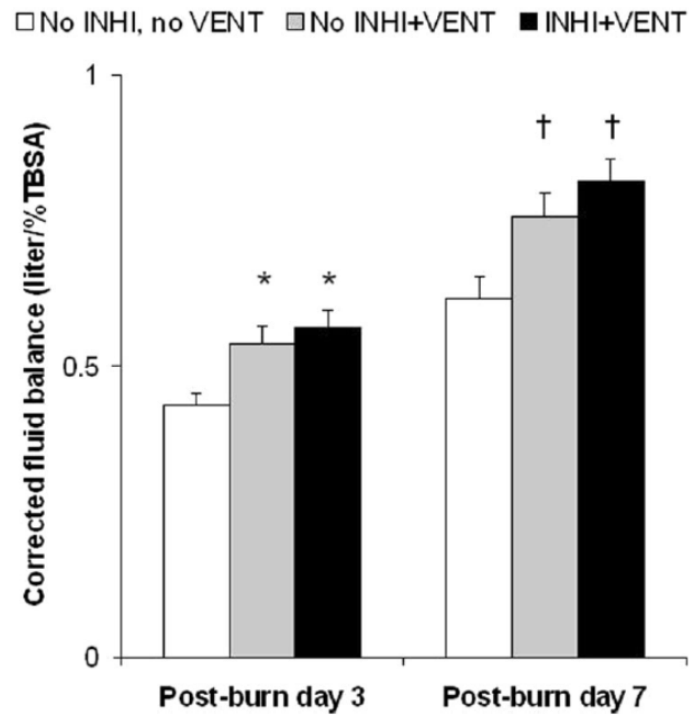



**Figure 1.** Representation of the cumulative fluid balance on days 3 and 7 corrected for %TBSA for the three groups of patients with or without INHI. VENT, mechanical ventilation. Data are represented as mean ± SEM. *†$p < 0.01$ versus INHI−CPPV− at days 3 and 7, respectively.

LINKÖPING UNIVERSITY

J Trauma. 2009 Dec;67(6):1233-8; discussion 1238.

# Mechanical ventilation and fluid retention in burn patients.

Mackie DP, Spoelder EJ, Paauw RJ, Knape P, Boer C.

Department of Anesthesiology, Burns Center, Red Cross Hospital, Beverwijk, the Netherlands.

## Abstract

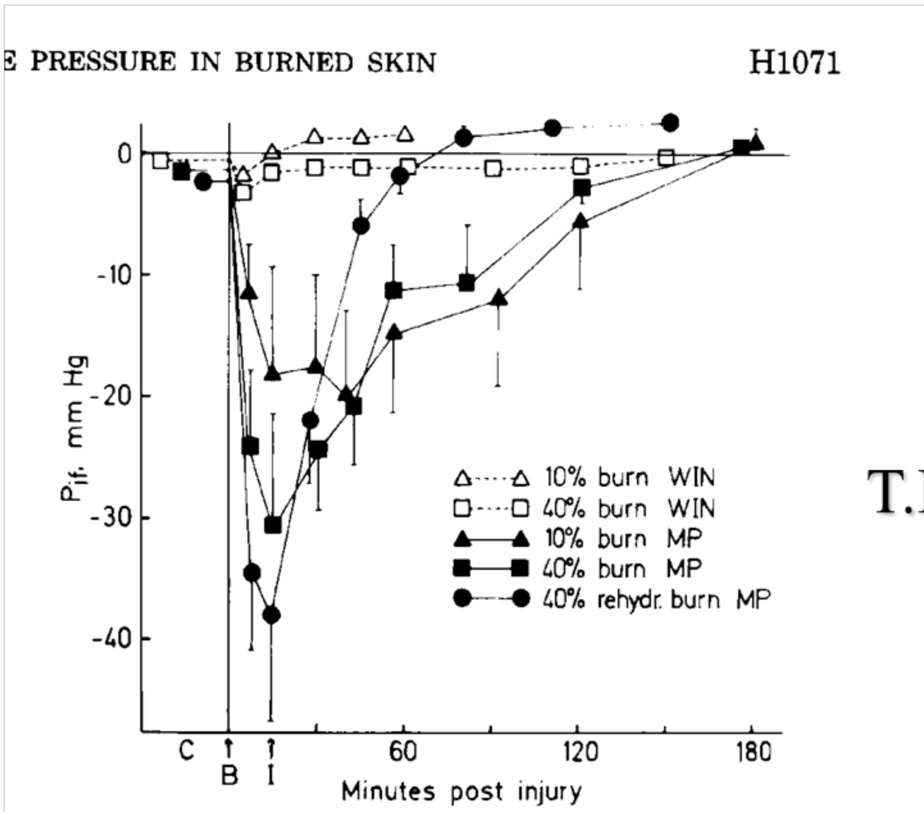
**BACKGROUND:** Burn patients with inhalation injury (INHI) require more fluid resuscitation than patients without INHI. However, the relation between INHI and fluid resuscitation may be confounded by a ventilation-induced increase in fluid retention. We therefore evaluated whether INHI was independently of continuous positive pressure ventilation (CPPV) associated with increased fluid retention.

**METHODS:** One hundred eighty-six patients with burns of >20% of total body surface area admitted to the Beverwijk Burns Center (1995-2006) were retrospectively studied. Cumulative fluid balance, defined as the total volume of fluids administered from the time of admission minus the total volume of fluids collected from each patient, was calculated at the end of days 3 (FB3) and 7 (FB7) postburn. The population was divided into three groups: (1) INHI-CPPV- (no INHI, no ventilation; n = 75); (2) INHI-CPPV+ (no INHI with ventilation; n = 62); and (3) INHI+CPPV+ (INHI with ventilation; n = 49). Analyses were corrected for differences in age, weight, and % total body surface area.

**RESULTS:** Patients who were mechanically ventilated were older and had more extensive burns than those who were not ventilated. Baseline characteristics of patients without INHI who were treated by CPPV were similar to patients with INHI, also treated by CPPV. FB3 was significantly higher in patients without INHI who were ventilated compared with nonventilated patients (13.4 +/- 5.8 L vs. 23.1 +/- 10.6 L for INHI-CPPV- and INHI-CPPV+ respectively, p = 0.001). However, fluid balance was not additionally affected by the presence of INHI. The difference in fluid retention between nonventilated and ventilated patients was also seen on day 7 (22.1 +/- 9.4 L vs. 34.2 +/- 15.9 L for INHI-CPPV- and INHI-CPPV+, respectively, p = 0.001).

**CONCLUSION:** These results suggest that increased fluid retention, which is conventionally associated with INHI, is due to the effects of ventilation and not to the effects of INHI itself. This warrants a closer evaluation of patients who are ventilated in the absence of INHI, with a view to early extubation.

# Arguments for a more rapid administration




Negative imbebition pressure

T.Lund et al. Am. J.Physiol 1988

# Arguments for a more rapid administration

1012 *E. Vlachou et al. / Burn.*

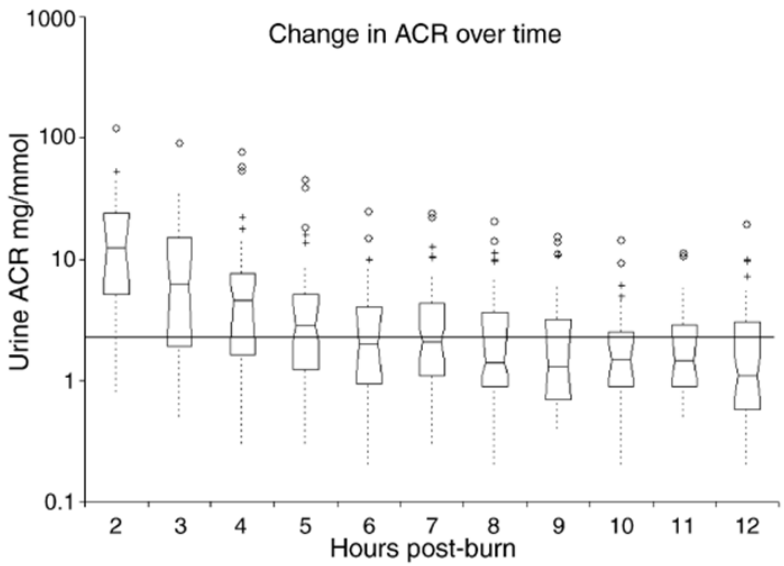



Fig. 1. Change in ACR/capillary leak following human thermal injury. The notched box shows the median, lower and upper quartiles, with confidence interval around the median. The dotted line connects the nearest observations within 1.5 IQRs (inter-quartile ranges) of the lower and upper quartiles. Crosses (+) and circles (○) indicate possible outliers—observations more than 1.5 IQRs (near outliers) and 3.0 IQRs (far outliers) from the quartiles, respectively.

Burns 32 (2006) 1009–1016

BURNS

www.elsevier.com/locate/burns

Microalbuminuria: A marker of endothelial dysfunction in thermal injury

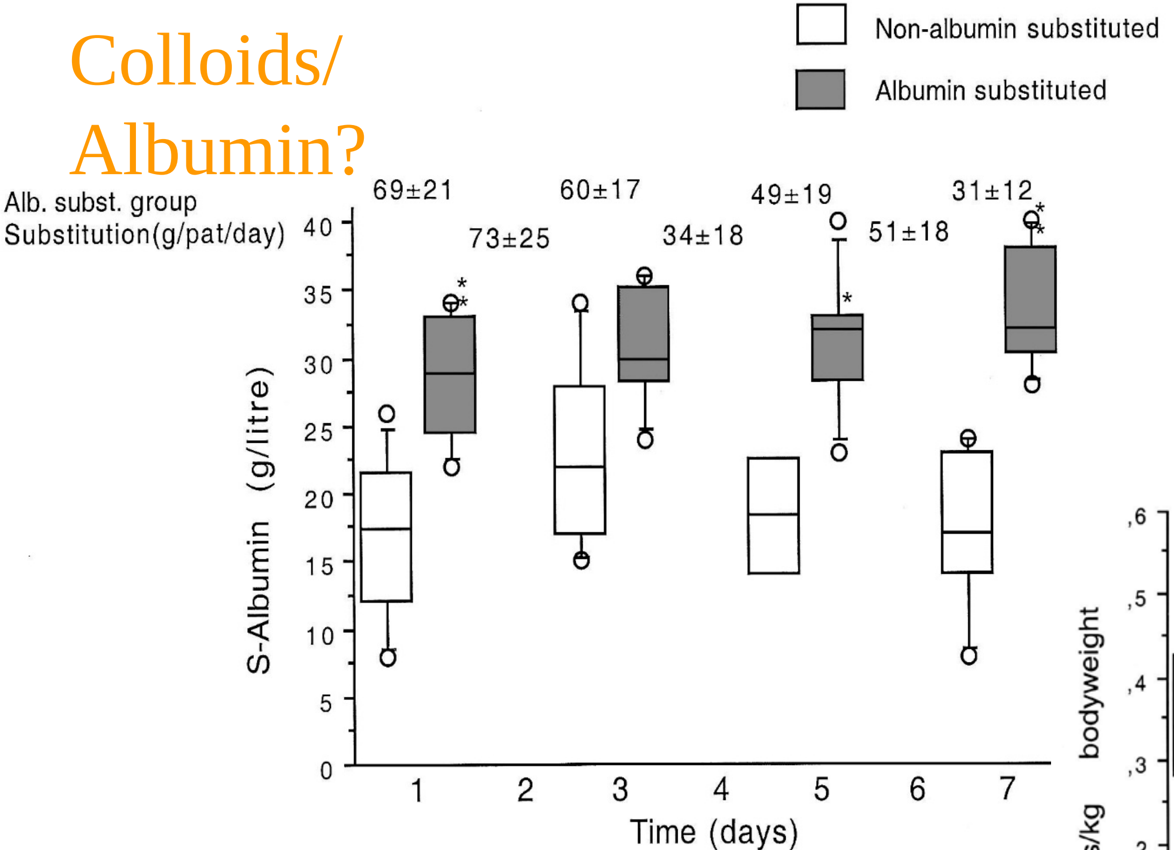
E. Vlachou *, P. Gosling, N.S. Moiemen

*University Hospital Birmingham, UK*

Accepted 27 February 2006

LINKÖPING UNIVERSITY

# Colloids/ Albumin?



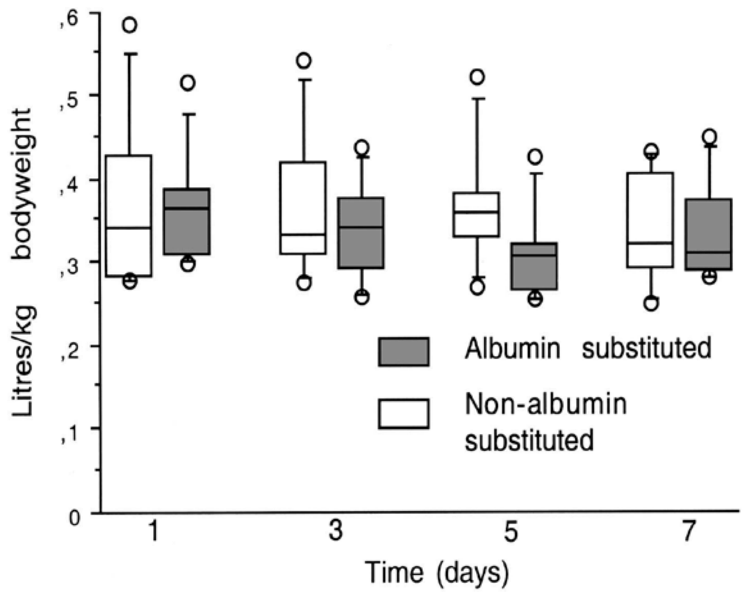

Intensive Care Med (2001) 27: 844–852
DOI 10.1007/s001340100935

ORIGINAL

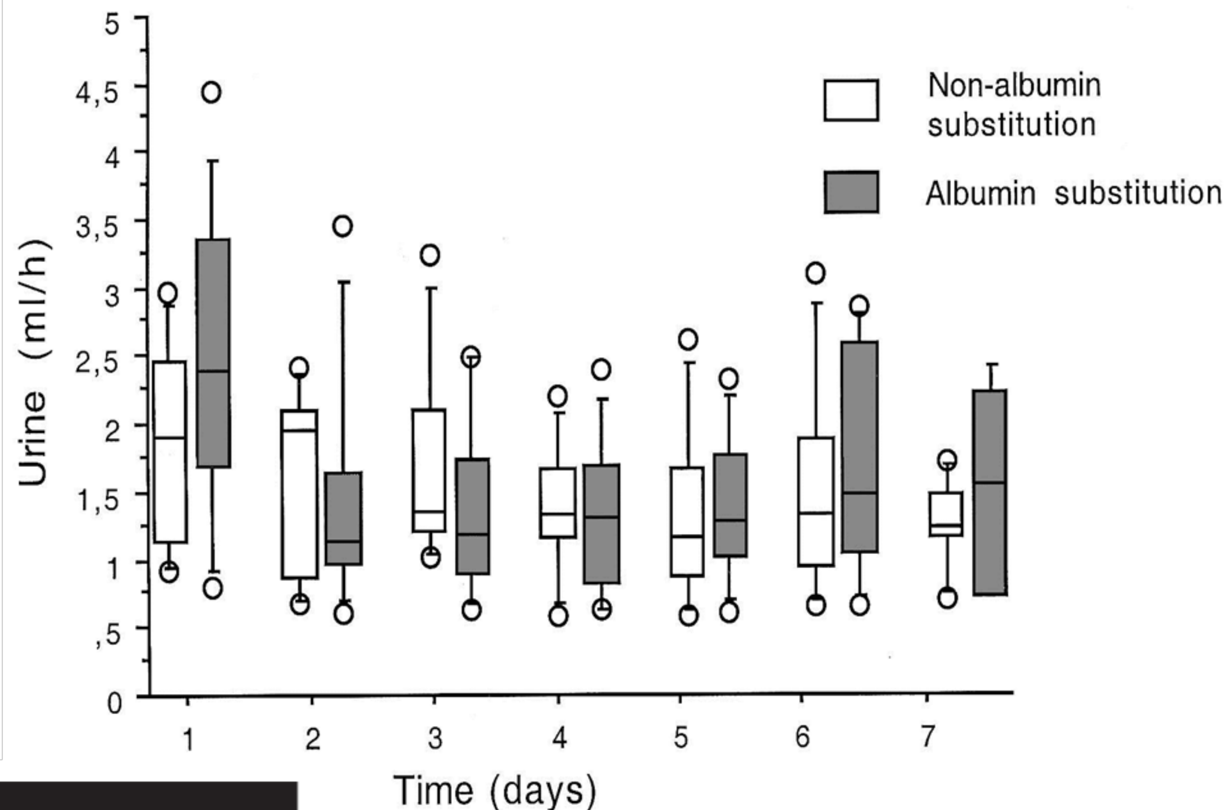
H.J. Zdolsek
B. Lisander
A.W. Jones
F. Sjöberg

**Albumin supplementation during the first week after a burn does not mobilise tissue oedema in humans**

## ECV



# Albumin?




Intensive Care Med (2001) 27: 844–852
DOI 10.1007/s001340100935

ORIGINAL

H.J. Zdolsek
B. Lisander
A.W. Jones
F. Sjöberg

**Albumin supplementation during the first week after a burn does not mobilise tissue oedema in humans**

Critical Care CRITICAL CARE



**Early fluid resuscitation with hyperoncotic hydroxyethyl starch 200/0.5 (10%) in severe burn injury**

*Critical Care* 2010, **14**:R123 doi:10.1186/cc9086

Markus Bechir (markus.bechir@usz.ch)
Milo A Puhan (milo.puhan@usz.ch)

**Table 2: Intervention**

| | | Baxter group (n=14) | HES group (n=16) |
|---|---|---|---|
| **Fluid volumes calculated for first 24h** | | | |
| Lactated Ringer's Solution [ml] | | 11150 ± 4115* | 7082 ± 5142 |
| HES [ml] | | 0 | 1409 ± 642 |
| **Fluid volumes given** | | | |
| Lactated Ringer's Solution [ml] | | | |
| | After 24h | 18667 ± 9438 | 12692 ± 4785 |
| | After 48h | 22220 ± 11340 | 16122 ± 5307 |
| | After 72h | 24903 ± 13093 | 18951 ± 7113 |
| HES [ml] | | | |
| | After 24h | 1 patient: 200 | 3431 ± 1674 |
| | After 48h | 2 patients: 200 each | 4966 ± 2461 |
| | After 72h | 4 patients: 1325 ± 538 | 6094 ± 3359 |
| Albumin [ml] | | | |
| | After 24h | 9 patients: 136 ± 70 | 0 |
| | After 48h | 13 patients: 438 ± 119 | 0 |
| | After 72h | 11 patients: 627 ± 205 | 1 patient: 200 |

* Values are means ± SD unless stated differently. HES indicates hydroxyethyl starch.

**Critical Care** CRITICAL CARE



**Early fluid resuscitation with hyperoncotic hydroxyethyl starch 200/0.5 (10%) in severe burn injury**

*Critical Care* 2010, **14**:R123 doi:10.1186/cc9086

Markus Bechir (markus.bechir@usz.ch)

## Key messages

- There ist some indication that HES 200/0.5 (10%) may be associated with increased mortality and renal failure in severe burn injury, but findings are not significant.
- HES 200/0.5 (10%) should be used with caution in severe burn injury.
- Successful surgery in burn injury is not affected by the application of HES 200/0.5 (10%).

# Fluid effects in skin during resuscitation

Research

**Open Access**

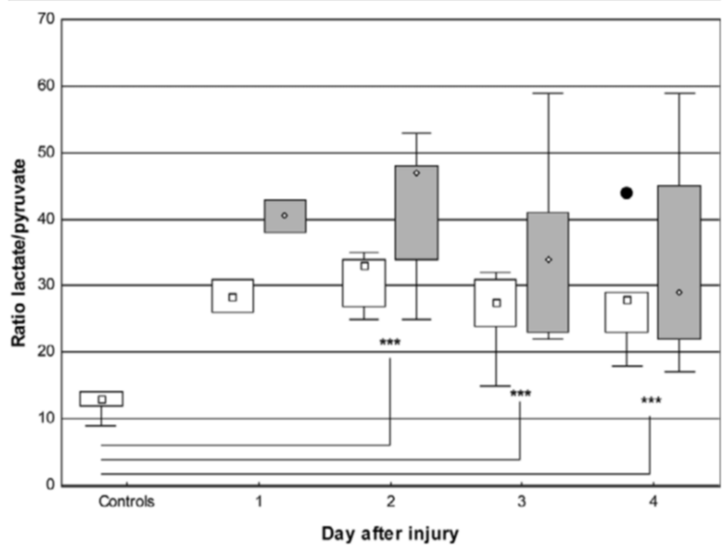
**Microdialysis shows metabolic effects in skin during fluid resuscitation in burn-injured patients**

*Critical Care* 2006, 10:R172 (doi:10.1186/cc5124)

Anders Samuelsson[1], Ingrid Steinvall[2] and Folke Sjöberg[1,2,3]

## Consequences for the tissues at normal "Parkland"

**Figure 4**




Box-and-whisker plots showing lactate/pyruvate ratio in microdialysate from days one to four. Open boxes indicate uninjured skin and controls; shaded boxes indicate burned skin. Controls, $n = 9$. Uninjured skin on day 1, $n = 2$; day 2, $n = 5$; day 3, $n = 6$; and day 4, $n = 5$. Burned skin on day 1, $n = 2$; day 2, $n = 5$; day 3, $n = 6$; and day 4, $n = 4$. $^{***}P <$ 0.001. Filled circle indicates outlier.

Research

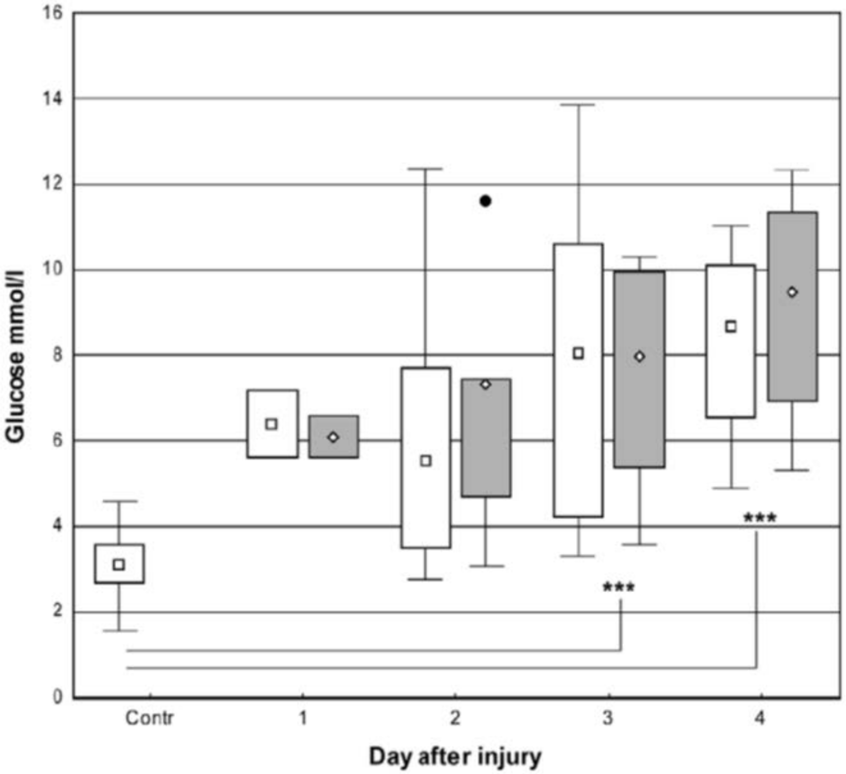
Open Access

# Microdialysis shows metabolic effects in skin during fluid resuscitation in burn-injured patients

Critical Care 2006, 10:R172 (doi:10.1186/cc5124)

Anders Samuelsson[1], Ingrid Steinvall[2] and Folke Sjöberg[1,2,3]

**Figure 1**




Box-and-whisker plots showing median (interquartile) glucose concentrations in microdialysate from days one to four. Open boxes indicate uninjured skin and controls; shaded boxes indicate burned skin. Filled circle indicates outlier (burned skin). Controls, $n = 9$. Uninjured skin on day 1, $n = 2$; day 2, $n = 5$; day 3, $n = 6$; and day 4, $n = 5$. Burned skin on day 1, $n = 2$; day 2, $n = 5$; day 3, $n = 6$; and day 4, $n = 4$. ***$P < 0.001$. Contr, control.

# Insulin resistance

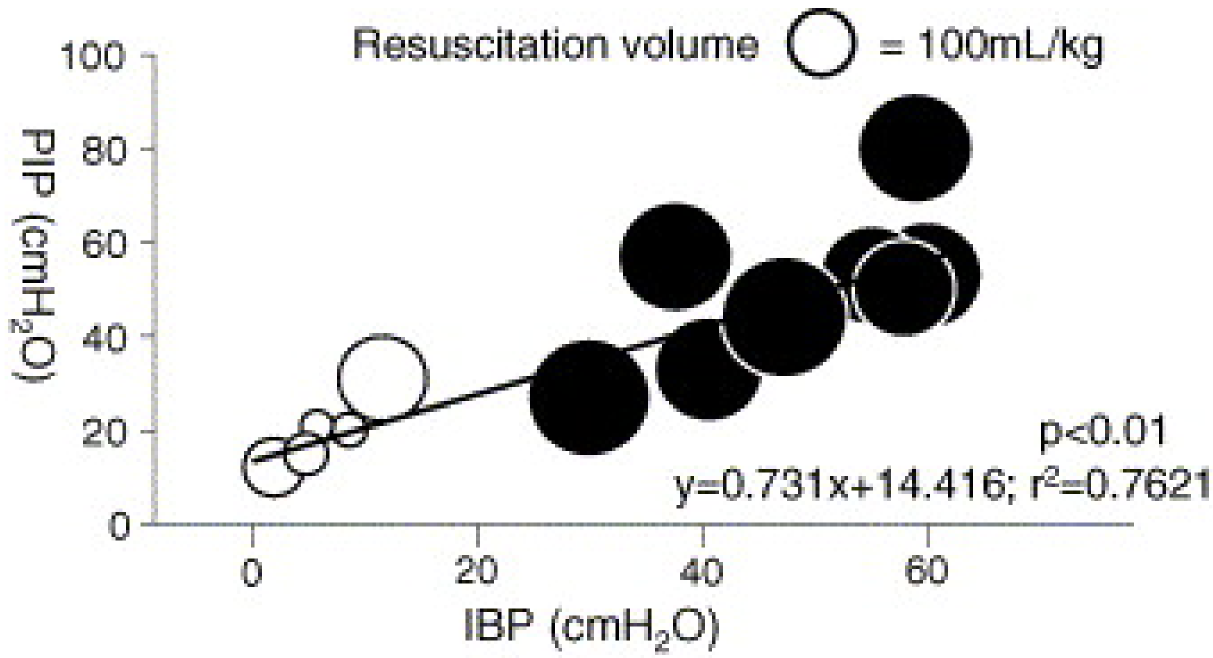



Fig. 2 Relationship among IBP, PIP, and resuscitation fluid volume (0–24<ce:hsp sp="0.25"/> h). (○): Patients without ACS; (●): patients with ACS; area of circle: the amount of fluid; IBP: intra-bladder pressure; PIP: peak inspiratory pressure.

Jun Oda , Katsuyuki Yamashita , Takuya Inoue , Nobuyuki Harunari , Yasumasa Ode , Kazuharu Mega , Yoshiki Aoki , ...

**Resuscitation fluid volume and abdominal compartment syndrome in patients with major burns**

Burns Volume 32, Issue 2 2006 151 - 154

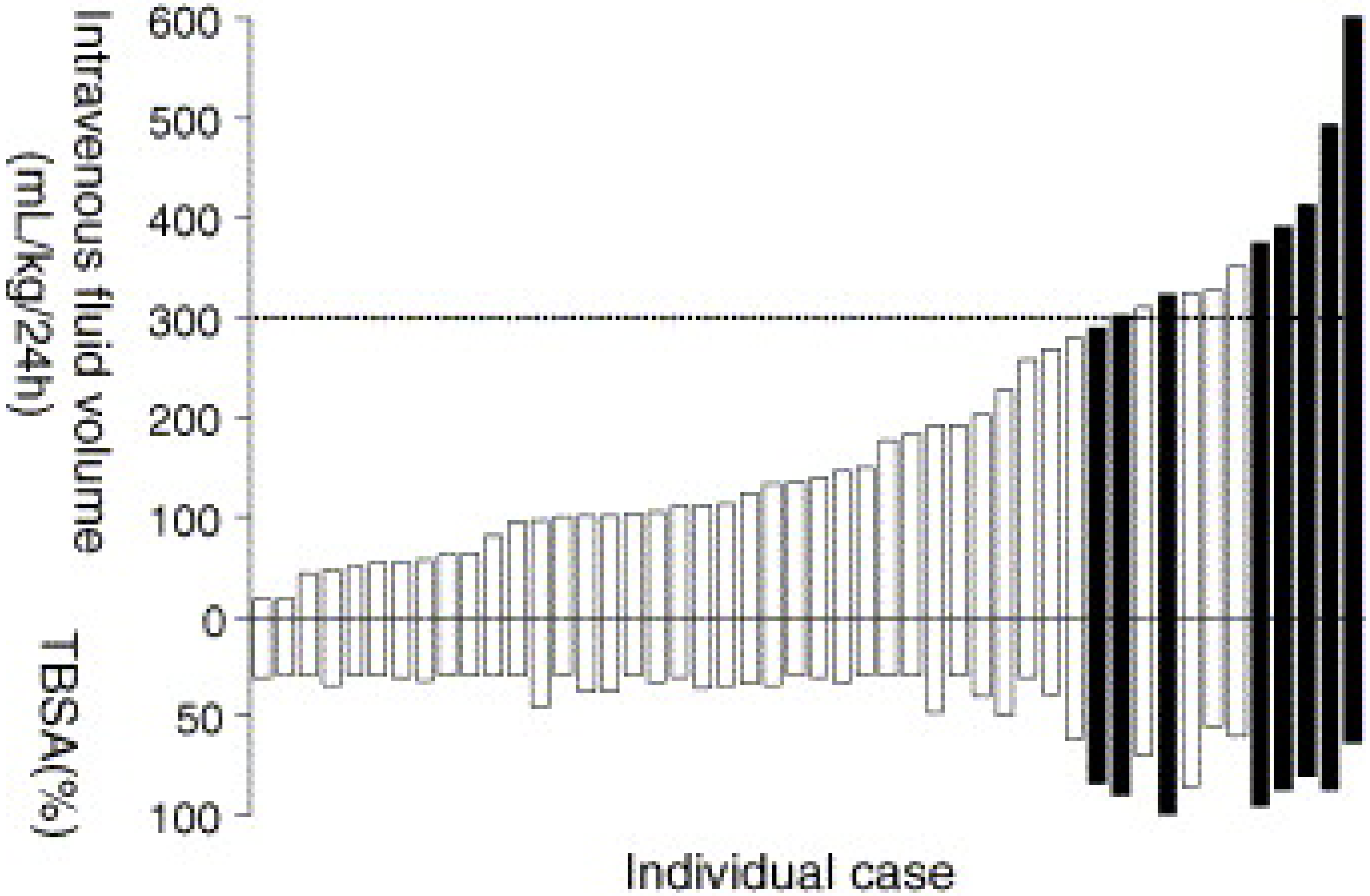



Fig. 2 Relationship among IBP, PIP, and resuscitation fluid volume (0–24<ce:hsp sp="0.25"/> h). (○): Patients without ACS; (●): patients with ACS; area of circle: the amount of fluid; IBP: intra-bladder pressure; PIP: peak inspiratory pressure.

Jun Oda , Katsuyuki Yamashita , Takuya Inoue , Nobuyuki Harunari , Yasumasa Ode , Kazuharu Mega , Yoshiki Aoki , ...

**Resuscitation fluid volume and abdominal compartment syndrome in patients with major burns**

Burns Volume 32, Issue 2 2006 151 - 154

TRANSFUSION PRACTICE

# Five percent albumin for adult burn shock resuscitation: lack of effect on daily multiple organ dysfunction score

*Andrew B. Cooper, Stephen M. Cohn, Haibo S. Zhang, Kim Hanna, Thomas E. Stewart, Arthur S. Slutsky, and the ALBUR Investigators*

**TRANSFUSION** 2006;46:80-89.

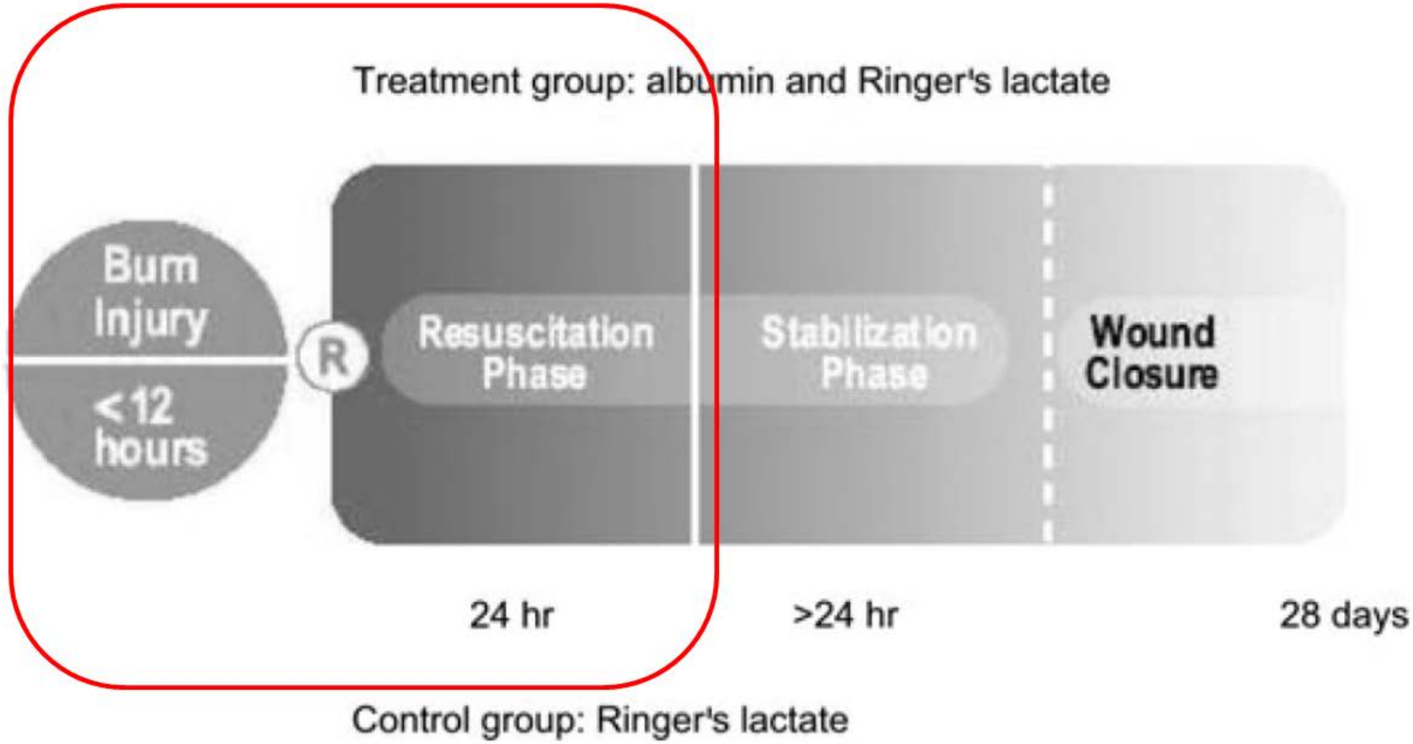



**Fig. 1. Overview of study design and plan. After randomization (R), the temporal relation to injury determined treatment fluid protocols until wound closure when treatment with the allocated resuscitation fluid stopped. Solid line = change in fluid administration rates after resuscitation; interrupted line = end of randomized treatment fluid administration.**

TRANSFUSION PRACTICE

**Five percent albumin for adult burn shock resuscitation: lack of effect on daily multiple organ dysfunction score**

*Andrew B. Cooper, Stephen M. Cohn, Haibo S. Zhang, Kim Hanna, Thomas E. Stewart, Arthur S. Slutsky, and the ALBUR Investigators*

**TABLE 3. Study fluid administration***

| Variable | Treatment group albumin and Ringer's (n = 19) | Control group Ringer's (n = 23) | P value |
|---|---|---|---|
| Resuscitation-phase infusions (mL) | | | |
| Basal | 1,308 (480-1,980) | 1,500 (720-2,450) | 0.27 |
| Treatment fluid | 3,355 (2,588-9,183) | 6,178 (3,435-9,481) | 0.42 |
| Other | 1,820 (300-5,197) | 1,039 (517-2,400) | 0.67 |
| Stabilization-phase infusions (mL) | | | |
| Basal | 1,649 (0-2,660) | 3,358 (1,875-4,250) | 0.02† |
| Treatment fluid | 232 (0-6,079) | 2,769 (0-14,314) | 0.39 |
| Other | 7,544 (1,595-16,865) | 3,194 (1,642-23,085) | 0.58 |

* Data are reported as median (95% CI).
† Wilcoxon two-sample test.

# ”Colloid rescue”

The Journal of TRAUMA® Injury, Infection, and Critical Care

## A Prospective, Randomized Evaluation of Intra-abdominal Pressures with Crystalloid and Colloid Resuscitation in Burn Patients

*Michael S. O'Mara, MD, Harvey Slater, MD, I. William Goldfarb, MD, and Philip F. Caushaj, MD*

**Table 1** Admission Data

| | Crystalloid | Plasma | *p* Value |
|---|---|---|---|
| No. | 15 | 16 | |
| Age (yr) | 46.4 ± 20.5 | 44.6 ± 19.3 | 0.79 |
| Weight (kg) | 88.5 ± 16.2 | 87.0 ± 10.3 | 0.47 |
| Total body surface area (%) | 50.1 ± 12.4 | 52.1 ± 12.4 | 0.67 |
| Full-thickness burn (%) | 28.3 ± 11.9 | 29.0 ± 18.9 | 0.91 |
| Inhalation injury | 11 | 10 | 0.70 |
| Escharotomy | 4 | 2 | 0.39 |
| Intra-abdominal pressure (mm Hg) | 5.8 ± 2.7 | 5.9 ± 3.5 | 0.95 |
| Creatinine (mg/dL) | 0.99 ± 0.22 | 1.03 ± 0.27 | 0.73 |
| Blood urea nitrogen (mg/dL) | 15.7 ± 4.3 | 17.3 ± 5.6 | 0.37 |
| Base excess/deficit | –4.5 ± 2.9 | –3.6 ± 2.5 | 0.40 |
| Peak airway pressure (mm Hg) | 29.2 ± 3.5 | 28.9 ± 3.2 | 0.83 |

*J Trauma.* 2005;58:1011–1018.

# "Colloid rescue"

The Journal of TRAUMA® Injury, Infection, and Critical Care

**A Prospective, Randomized Evaluation of Intra-abdominal Pressures with Crystalloid and Colloid Resuscitation in Burn Patients**

Michael S. O'Mara, MD, Harvey Slater, MD, I. William Goldfarb, MD, and Philip F. Caushaj, MD

**Table 2** **Initial Resuscitation Data (24 h)**

| | Crystalloid | Plasma | *p* Value |
|---|---|---|---|
| No. | 15 | 16 | |
| Peak IAP (mm Hg) | 11.7 ± 2.9 | 8.4 ± 3.0 | 0.003 |
| IAP increase (mm Hg) | 6.1 ± 3.5 | 2.1 ± 3.5 | 0.006 |
| Predicted volume (L) | 17.1 ± 6.4 | 8.5 ± 0.8 | <0.0001 |
| Actual volume (L) | 22.1 ± 12.8* | 12.3 ± 9.3* | 0.02 |
| Predicted volume (L/kg) | 0.20 ± 0.05 | 0.10 ± 0.05 | <0.0001 |
| Actual volume (L/kg) | 0.26 ± 0.12* | 0.14 ± 0.10* | 0.005 |
| Urine output (mL/kg/h) | 0.77 ± 0.21 | 0.76 ± 0.33 | 0.6 |

* No significant difference between predicted and actual volumes, $p > 0.1$ in all cases.

*J Trauma.* 2005;58:1011–1018.

# "Colloid rescue"

The Journal of TRAUMA® Injury, Infection, and Critical Care

## A Prospective, Randomized Evaluation of Intra-abdominal Pressures with Crystalloid and Colloid Resuscitation in Burn Patients

*Michael S. O'Mara, MD, Harvey Slater, MD, I. William Goldfarb, MD, and Philip F. Caushaj, MD*

**Table 6** Peak Data

| | Crystalloid | Plasma | *p* Value |
|---|---|---|---|
| No. | 15 | 16 | |
| Peak IAP (mm Hg) | 32.5 ± 9.5 | 16.4 ± 7.5 | <0.0001 |
| IAP increase (mm Hg) | 26.5 ± 7.9 | 10.6 ± 6.4 | <0.0001 |
| Time of peak IAP (hr) | 72.7 ± 4.1 | 68.3 ± 11.1 | 0.16 |
| Resuscitation volume (L/kg) | 0.561 ± 0.160 | 0.360 ± 0.170 | 0.0021 |
| Weight gain (%) | 40.7 ± 17.8 | 15.3 ± 10.0 | <0.0001 |
| Urine output (ml/kg/h) | 0.54 ± 0.26 | 0.83 ± 0.32 | 0.0097 |
| Peak creatinine (mg/dL) | 1.9 ± 1.0 | 1.5 ± 0.9 | 0.23 |
| Peak BUN (mg/dL) | 30.2 ± 13.4 | 24.6 ± 15.7 | 0.29 |
| Peak base excess/deficit | –1.7 ± 5.5 | 1.3 ± 3.2 | 0.07 |
| Peak PAP (mm Hg) | 40.6 ± 5.6 | 35.2 ± 5.4 | 0.01 |

*J Trauma.* 2005;58:1011–1018.

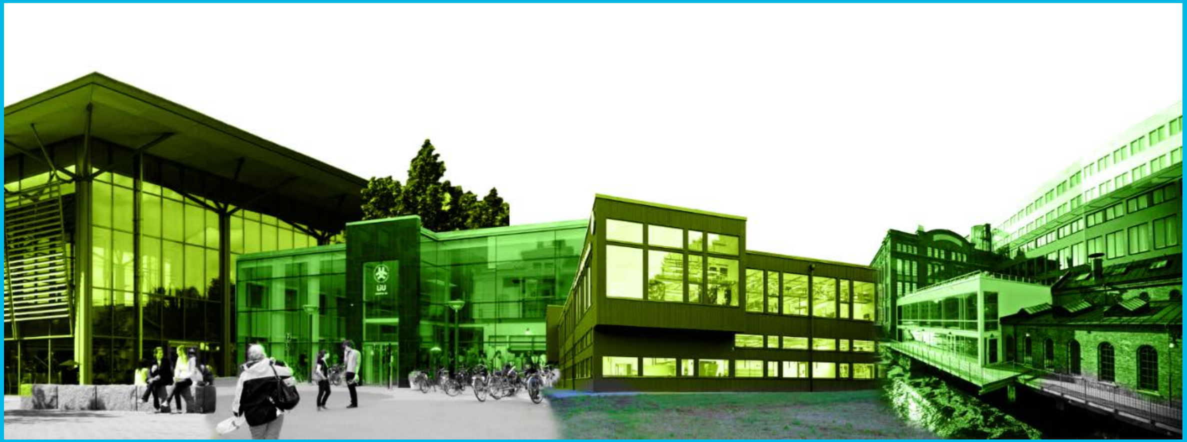
# Conclusion:

- In larger burns use “colloid rescue” to avoid over resuscitation and compartment issues

# Conclusion
# Parkland
# – close surveillance
# Urinary output

# Thank you!

www.liu.se



LINKÖPING UNIVERSITY