ABSTRACT: The impact of major burn trauma on patients and health care systems is enormous. This is due in part to the complex physiology of burns and the need for multidisciplinary medical and surgical management. Some aspects of this management are the subject of ongoing clinical controversy. To address the challenges faced by medical personnel caring for burn patients in different settings, a multidisciplinary group of physicians collaborated in 2010 to systematically review the literature on burn resuscitation and conduct an internal audit of burn care at the BC Professional Fire Fighters’ Burn, Plastic and Trauma Unit in Vancouver. The results of the literature review and audit were then used to develop the Adult Major Burns Clinical Practice Guidelines now available to practitioners throughout BC. These guidelines include best-practice protocols and serve as a resource for the resuscitation of adult major burn patients in prehospital, rural, and tertiary care settings. The guidelines recognize that comprehensive major burn care requires the skills of many health professionals, including rural emergency physicians and critical care transport paramedics.

Major burn trauma (MBT) represents a relatively small subset of major trauma, yet the impact on patients and health care systems is enormous, in part due to the complex physiology of burns and the need for multidisciplinary medical and surgical management.

History of major burn trauma resuscitation

Historical experience, especially from world conflicts in the early 20th century, made clear that patients with major burn trauma commonly died from severe hypovolemia and acute renal failure in the early days post-trauma. Seminal research by Underhill, Cope, Moore, and others was followed by the work of Drs Baxter and Shires at Parkland Memorial Hospital in Dallas, Texas, that further recognized and promoted the importance of early, aggressive fluid resuscitation to re-establish intravascular volume to improve early survival.1,2 In a retro-

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A multidisciplinary working group has developed guidelines based on a literature review and an audit of major burn resuscitation at the BC Professional Fire Fighters’ Burn, Plastic and Trauma Unit.
spective analysis of major burn trauma, Baxter noted that patients who were resuscitated in the first 24 hours posttrauma with a crystalloid solution of between 3 and 5 millilitres per kilogram per percentage of total body surface area (mL/kg/%TBSA) burned had lower mortality rates than patients who received less fluid. The resuscitation benchmark of 4 mL/kg/%TBSA in the first 24 hours posttrauma became known as the Parkland formula. This remains the burn resuscitation formula most widely used today. Baxter also experimented with different kinds of resuscitation fluids, including crystalloids, colloids, and blood products. Over 40 years later, the choice of resuscitation fluid remains a topic of ongoing controversy.1

The intersection of modern military conflicts and advanced trauma care has significantly increased our experience with major burn trauma.3,4 Relatively recently, burn specialists began to notice an important subset of patients suffering significant morbidity and mortality related to over-resuscitation with fluids.5-7 Complications such as acute respiratory distress syndrome, congestive heart failure, cerebral edema, sepsis, and extremity or abdominal compartment syndrome were specifically associated with resuscitation volumes in excess of 6 mL/kg/%TBSA burned in the first 24 hours and were also associated with a steep increase in mortality.4 “Fluid creep,” as it became known, emerged as a new threat to major burn trauma patients, and experts called for a reassessment of resuscitation protocols to address these potentially avoidable complications.5,6,8

In light of changing perspectives on burn pathophysiology, the Canadian and American military and the American Burn Association now specify a resuscitation formula of 2 to 4 mL/kg/%TBSA burned for the first 24 hours, with the lower figure in this range being half of what the Parkland formula endorses.5 Many other major trauma systems have adopted resuscitation formulas of less than 4 mL/kg/%TBSA in the first 24 hours,4,9 including formulas based on the Lund-Browder chart.10 In addition to new concepts in fluid resuscitation for burns, novel therapies such as high-dose vitamin C,9,11,12 early colloid administration, and selective use of vasoactive agents to improve perfusion pressures are also gaining traction in complex burn care.9

Management of major burn trauma in BC

In British Columbia major burn care is delivered in two centres. The Royal Jubilee Hospital Burn Unit in Victoria provides burn care for the Vancouver Island Health Authority (VIHA) and handles select provincial referrals. The BC Professional Fire Fighters’ Burn, Plastic and Trauma Unit (BPTU) at Vancouver General Hospital (VGH) serves as the quaternary referral centre for major burn trauma for the province. Primary burn medical and surgical care is led by clinical specialists from the Division of Plastic Surgery, though comprehensive care is multidisciplinary and includes paramedics, emergency physicians, intensive care physicians, trauma surgeons, and anesthesiologists, as well as specialized nurses and other allied health care professionals.

Recently, burn specialists began to notice an important subset of patients suffering significant morbidity and mortality related to over-resuscitation with fluids.

With burn care changing, an ad hoc working group on major burn trauma was assembled in 2010 to review the literature and update regional practice standards for major burn resuscitation. The MBT group sought to engage tertiary and rural care providers to improve province-wide burn management using an inclusive, multidisciplinary model. Specialist physicians from plastic surgery, trauma surgery, anesthesia, critical care medicine, emergency medicine, and prehospital care were represented. This group met regularly over a 1-year period and performed a systematic review of the medical literature to scrutinize international practice patterns and standards for major burn resuscitation. An internal audit of major burn resuscitation was also performed at the BPTU to identify areas of clinical strength and areas for improvement. Over the course of this process, the MBT group focused on
Table. Issues identified by the MBT group and actions recommended to improve major burn trauma resuscitation in British Columbia.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Consequence</th>
<th>Action</th>
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<tr>
<td>1. 50% of major burn trauma patients referred to the BC Professional Fire Fighters’ Burn, Plastic and Trauma Unit (BPTU) over the last 10 years were from outside the Lower Mainland. Transfer times ranged from 2–26 hours (mean, 18 hours).</td>
<td>Rural emergency physicians, family physicians, and paramedics spend an important portion of the first 24 hours posttrauma with major burn patients.</td>
<td>Major Burns Clinical Practice Guidelines (CPGs) were developed to improve assessment and early management. Recommendations include resuscitation algorithms that prehospital and rural medical care providers can use.</td>
</tr>
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<td>2. Estimates of total body surface area (TBSA) burned made by different care providers varied enormously.</td>
<td>Fluid resuscitation based on inaccurate TBSA estimates can lead to complications. Higher rates of abdominal compartment syndrome were noted in patients when TBSA calculations were overestimated (unpublished data collected by Drs Gregory and Papp at the BPTU in 2011).</td>
<td>A TBSA estimation chart based on the Lund-Browder chart was included in the Major Burns CPGs to improve inter-user reliability and reduce the variability of resuscitation fluid volumes administered.</td>
</tr>
<tr>
<td>3. 85% of major burn patients referred to the BPTU were over-resuscitated by an average of 10%.</td>
<td>Inadvertent over-resuscitation with crystalloid (beyond 4 mL/kg/%TBSA in the first 24 hours) can be responsible for significant, preventable contributions to subsequent morbidity and mortality.</td>
<td>The resuscitation formula in the Major Burns CPGs (3 mL/kg/%TBSA in the first 24 hours) was included to reflect current consensus recommendations.</td>
</tr>
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<td>4. Hemodynamically unstable patients were commonly treated with successive fluid boluses, while the use of vasoactive agents was avoided.</td>
<td>Inadvertent over-resuscitation with crystalloid (beyond 4 mL/kg/%TBSA in the first 24 hours) can be responsible for significant, preventable contributions to subsequent morbidity and mortality.</td>
<td>Hemodynamic instability was addressed in the Major Burns CPGs with recommendations on selective use of colloids and vasoactive agents.</td>
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Resuscitation in the first 24 hours. This approach was taken for two reasons:
- Resuscitation in the first 24 hours has a significant impact on morbidity and mortality later in a patient’s care.
- Medical and surgical management after the first 24 hours rapidly becomes extremely complex and beyond the scope of the MBT group’s mandate.

After reviewing, debating, and discussing the scientific literature and the results of the internal BPTU audit, the MBT group identified four clinically significant issues (see the Table):
- Many patients were transferred to the BPTU from outside the Lower Mainland after time had elapsed (2 to 26 hours).
- Health personnel estimates of the percentage of TBSA burned varied widely.
- The majority of patients referred to the BPTU were found to be over-resuscitated.
- Hemodynamically unstable patients were commonly treated with successive fluid boluses, while the use of vasoactive agents was avoided.

MBT group members agreed that a set of clinical practice guidelines (CPGs) should be developed to summarize the results of their literature review and address the issues identified. Initially, the goal of this initiative was to improve local hospital (VGH) practice; however, input from regional and provincial trauma leaders soon prompted the MBT group to collaborate with burn physicians at VIHA and to expand their mandate provincially.

The Adult Major Burns CPGs that resulted (see Figures 1–5) were designed using human factors engineering principles. They are practical, easy to use, and reflect best practice in major burn management. Currently, copies of the CPGs can be downloaded from http://apt.ubc.ca/hospital-sites/vancouver-general-hospital/clinical-practice-guidelines/. In the near future, the CPGs will be available through the Provincial Health Services Authority at www.bcguidelines.ca.

Moving forward with burn care in BC
The Adult Major Burns CPGs were introduced into clinical practice at Vancouver General Hospital in the summer of 2011 and shortly after were adopted by BC Ambulance critical care transport paramedics. Physician leaders in Vancouver, Victoria, and other provincial health authorities are now using CME lectures, newsletters, scientific publications, and electronic media to disseminate the CPGs to all emergency health care providers in the province. To date, the CPGs have been field tested during two major industrial burn trauma scenarios in northern BC, and in major burn trauma cases elsewhere in the province. Informal feedback regarding the structure and usability of the CPGs...

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Figure 1. First 12 Hours Post Burn.

This guideline outlines an initial approach to fluid resuscitation for major burn trauma. Note that the resuscitation formula recommended in step 3 (Ringer's Lactate 3 mL/kg/%TBSA) is to be titrated according to clinical end points (i.e., urine output).
12 Hour Assessment  

**Adult Major Burns Clinical Practice Guidelines**

To be completed 12 hours post burn. Please note that this is a guideline only, not a substitute for clinical judgement.

Calculate total fluid given in first **12** hours (since time of burn):

Equals [A] _____ml

Multiply [A] x 2 for projected fluid administration in 24 hours:

Equals [B] _____ml

Calculate projected fluid administration for 6ml/kg/TBSA:

Equals [C] _____ml

If [B] is larger than [C]:
- Alert burn/ICU physician
- Consider albumin protocol*
- Check bladder pressures q4h
- If urine output > 50ml/hr, decrease IV fluid administration rate by 20% (measure q1h)

If [B] is less than [C]: continue resuscitation according to Major Burn CPG.

*Albumin protocol: Albumin 5% at 1/3 current rate plus RL at 2/3 current rate

**Figure 2. 12 Hour Assessment.**

This worksheet is designed to assist with early identification of over-resuscitation with fluids.
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Figure 3. TBSA Burn Estimation Chart.

This chart is based on the Lund-Browder TBSA assessment chart, which has high inter-user reliability. When used as the standard TBSA assessment tool, the chart can reduce the variability of resuscitation fluid volumes administered.
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Figure 4. Resuscitation Flow Sheet.

This worksheet records resuscitation details for the first 24 hours posttrauma. Note that the two "stop checks" to assess total resuscitation fluids administered at 12 and 24 hours are designed to assist with early identification of over-resuscitation.
Figure 5. ICU

ICU

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>General Management</th>
<th>Initial Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Intraocular arterial blood pressure</td>
<td>□ HRB ≥ 30°</td>
<td>□ Urine output minimum 30ml/h maximum 50ml/h</td>
</tr>
<tr>
<td>□ CVC (preferably supradiaphragmatic)</td>
<td>□ Gastric prophylaxis</td>
<td>□ Temperature ≥ 37°C</td>
</tr>
<tr>
<td>□ SvO₂ q3h X 24 then R/A</td>
<td>□ DVT prophylaxis</td>
<td>□ MAP ≥ 65mmHg</td>
</tr>
<tr>
<td>□ CVP as per ICU protocols</td>
<td>□ Burn dressings as per Plastic Surgery</td>
<td>□ SvO₂ ≥ 70%</td>
</tr>
<tr>
<td>□ Lactate q3h X 24-72h</td>
<td>□ Elevate all burned body parts when possible</td>
<td>□ Lactate ≤ 4mmol/L</td>
</tr>
<tr>
<td>□ ABGs as per ICU protocols</td>
<td>□ Start uninterrupted enteral feeds as early as possible (as per Dietitian) unless legitimate concern of splanchic hypoperfusion or abdominal compartment syndrome</td>
<td>□ Hgb ≥ 70g/L</td>
</tr>
<tr>
<td>□ Bladder pressures q6h from 12-72h post burn</td>
<td>□ Fecal contamination system for perineal burns as directed by ICU or Burn physician</td>
<td>□ Platelets ≥ 50 (Actively bleeding or imminently going to OR)</td>
</tr>
<tr>
<td>□ For facial burns or inhalation injury: - Consult Ophthalmology</td>
<td>□ Attempt to minimize opioid infusion administration and utilize pin opioids as soon as feasible</td>
<td>□ INR ≤ 1.5 (Actively bleeding or imminently going to OR)</td>
</tr>
</tbody>
</table>

Initial Fluid Resuscitation

**STEP 1** Calculate initial 24 hour resuscitation fluid requirements = (3ml of Ringers Lactate[kg] (%) TBSA from Plastics consult / 24h, 1% of this IVF is administered in the first 8 hours (post burn) and the second 6% is delivered in the remaining 16 hours.

**STEP 2** Determine the administered pre-hospital IVF volume, subtract this from your above calculation, and adjust your treatment appropriately.

**STEP 3** Monitor urine output hourly and decrease or increase the RL infusion by 20% to maintain urine output between 30-50ml/hr. Avoid boluses if possible. **NOTE:** Hour to hour fluid resuscitation is critical, particularly during first 24 hours. OVER-RESUSCITATION IS AS HARMFUL AS UNDER-RESUSCITATION.

**STEP 4** If urine output is ≤ 15ml/hr for two or more consecutive hours despite increasing fluid rate OR patient requires twice current calculated rate for more than two hours:

CALL ICU FELLOW OR ATTENDING, flush urinary catheter, assess breath sounds and bladder pressure. Consider initiating 5% albumin infusion at 1/3 of current resuscitation rate and make up the remainder of rate with RL. Titrate infusion to urine output as described above. After 24 hours post burn, titrate infusion down to maintenance and continue albumin by 48 hours post burn.

**STEP 5** At 12 hours post burn, calculate the PROJECTED 24 hour resuscitation if fluid rates are constant. If the projected 24 hour resuscitation requirement exceeds 6ml/kg% TBSA burn or 350ml/kg total, the following steps are recommended:

1. **Initiate 5% albumin infusion at 1/3 of current resuscitation rate and make up the remainder of rate with RL. Titrate infusion to urine output as described above.** After 24 hours post burn, titrate infusion down to maintenance and continue albumin by 48 hours post burn.
2. **Watch for signs of Intra-Abdominal Hypertension (bladder pressure ≥ 15mmHg, increased airway pressures, decreased urine output, hypotension) and compartment syndromes (absent diastolic signal or pulses that are diminishing on serial exams q30-60 minutes should prompt consideration of excisionotomy).**

**Recommendations for True Hypotension MUST BE correlated with urine output.**

1. **Volume Status:** If CVP ≤ 5mmHg or pulse pressure variation ≥ 15mmHg and patient is not breathing spontaneously, administer a fluid bolus of 0.5-1L in attempt to improve MAP (it is UNCONTRAINDED to achieve CVP goal of 10-12mmHg in severe burn patients).
2. **Vasopressors:** If MAP is persistently ≤ 55mmHg initiate Levophed at 1:20 ug/min to maintain MAP ≥ 65mmHg (massive burn patients commonly require Levophed 1:5-15ug/min to achieve vasodilatory shock secondary to the massive systemic inflammatory response associated with severe burns).
3. **MAP Goal:** If persistently requiring levophed (1-Sug/min) consider a MAP goal of ≥ 65mmHg as long as urine output ≥ 30ml/hr, SvO₂ ≥ 70% and lactate ≤ 4mmol/L.
4. **Ca²⁺ and Cortisol (discuss with ICU fellow/attending before initiation of treatment):** If patient exhibits catecholamine-resistant shock (defined as SBP ≤ 90mmHg after 1 hour of aggressive IVF and vasopressor administration), consider adrenal insufficiency (check a random cortisol and start hydrocortisone 100mg IV q6h) or hypocalemia (maintain ionized calcium ≥ 1.1 mmol/L (1.5).

The Adult Major Burns CPGs were developed to improve the burn care delivered by all health care personnel in British Columbia. The guidelines provide up-to-date information regarding fluid resuscitation in the first 24 hours after burn trauma, and guidance on obtaining more accurate assessment of the TBSA burned using the Lund-Browder chart. This information is intended for all levels of care providers and should help reduce variability in fluid resuscitation calculations. Information is also provided to improve care in some major burns cases that require the selective use of colloid and vasoactive agents.

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unintended under-resuscitation of major burn trauma patients, and that this will compromise end-organ function.

Summary
The management of major burns is challenging and requires multidisciplinary care. Prehospital personnel and rural emergency physicians spend an important portion of time with major burn trauma patients, and the care these practitioners provide early in the resuscitation process has a major impact on patient morbidity and mortality later on.

The Adult Major Burns CPGs were developed to improve the burn care delivered by all health care personnel in British Columbia. The guidelines provide up-to-date information regarding fluid resuscitation in the first 24 hours after burn trauma, and guidance on obtaining more accurate assessment of the TBSA burned using the Lund-Browder chart. This information is intended for all levels of care providers and should help reduce variability in fluid resuscitation calculations. Information is also provided to improve care in some major burns cases that require the selective use of colloid and vasoactive agents.

The guidelines will be reviewed and updated regularly, and all feedback is welcomed by the MBT group. Feedback regarding this and other concerns can be directed to Dr Anthony Papp (anthony.papp@vch.ca ) and Dr Mark Vu (mark.vu@vch.ca).

Acknowledgments
The MBT group gratefully acknowledges the ongoing assistance of the Department of Plastic Surgery at Royal Jubilee Hospital and the Critical Care Transport Program of the BC Ambulance Service.

Competing interests
None declared.

References