Sol Gregory, MD, Mark Vu, MD, FRCPC, David Sweet, MD, MPH, FRCPC, Erik Vu, MD, FRCPC, Gordon Finlayson, MD, FRCPC, Ross Brown, OMM, CD, MA, MD, FRCPC, FACS, Alec Ritchie, MD, FCCFP, Donald Griesdale, MD, MPH, FRCPC, Vinay Dhingra, MD, FRCPC, Anthony Papp, MD, FRCPC

Provincial clinical practice guidelines for the management of major burn trauma

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.

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-

Dr Gregory is senior resident in the Division of Plastic Surgery at the University of British Columbia. Dr Mark Vu is section head, Trauma Anesthesia in the Department of Anesthesiology and Perioperative Care at Vancouver General Hospital (VGH). Dr Sweet is a staff physician in the Division of Critical Care Medicine at VGH and in the hospital's Department of Emergency Medicine. Dr Erik Vu is a staff physician in the Department of Emergency Medicine at VGH and the Department of Critical Care at Surrey Memorial Hospital, and a medical consultant for the British Columbia Ambulance Service. Dr Finlayson is a staff physician in the Division of Critical Care Medicine at VGH and in the hospital's Department of Anesthesiology and Perioperative Care. Dr Brown is medical director of trauma services for the British Columbia Provincial Health Services Authority. He is also a staff surgeon in the Division of General Surgery at VGH. Dr Ritchie is former head of the Department of Emergency Medicine at Lions Gate Hospital. Dr Griesdale is a staff physician in the Division of Critical Care Medicine at VGH and in the hospital's Department of Anesthesiology and Perioperative Care. Dr Dhingra is a staff physician in the Division of Critical Care Medicine at VGH. Dr Papp is director of the BC Professional Fire Fighters' Burn, Plastic and Trauma Unit at VGH. He is also a staff surgeon in the hospital's Division of Plastic Surgery.

This article has been peer reviewed.

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.[4] 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]

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

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.

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, anesthesiology, 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.

Issue	Consequence	Action
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).	Rural emergency physicians, family physicians, and paramedics spend an important portion of the first 24 hours posttrauma with major burn patients.	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.
2. Estimates of total body surface area (TBSA) burned made by different care providers varied enormously.	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).	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.
3. 85% of major burn patients referred to the BPTU were over-resuscitated by an average of 10%.	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.	The resuscitation formula in the Major Burns CPGs (3 mL/kg/%TBSA in the first 24 hours) was included to reflect current consensus recommendations.
4. Hemodynamically unstable patients were commonly treated with successive fluid boluses, while the use of vasoactive agents was avoided.	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.	Hemodynamic instability was addressed in the Major Burns CPGs with recommendations on selective use of colloids and vasoactive agents.

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

Continued on page 464

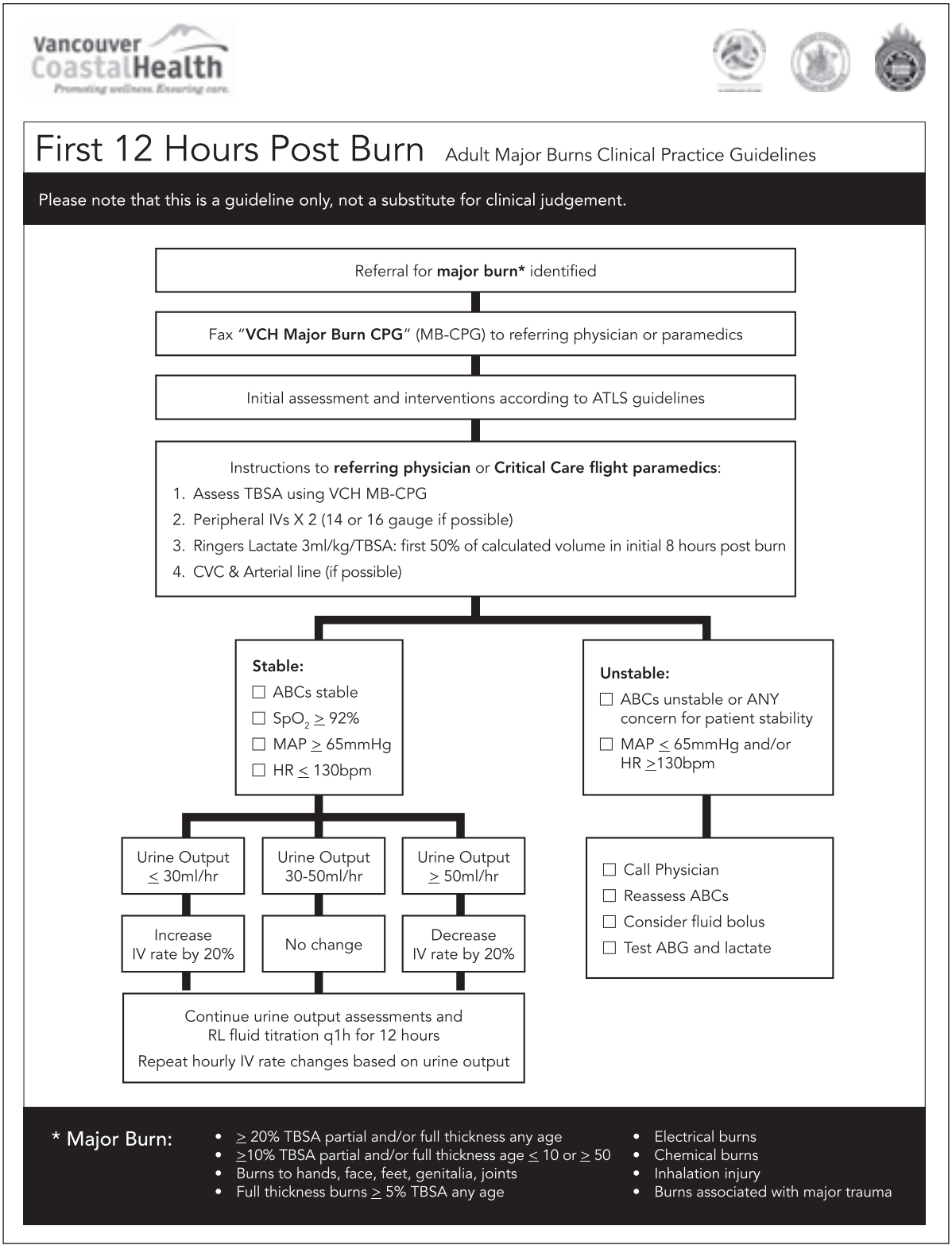


Figure 1. ***First 12 Hours Post Burn.***

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

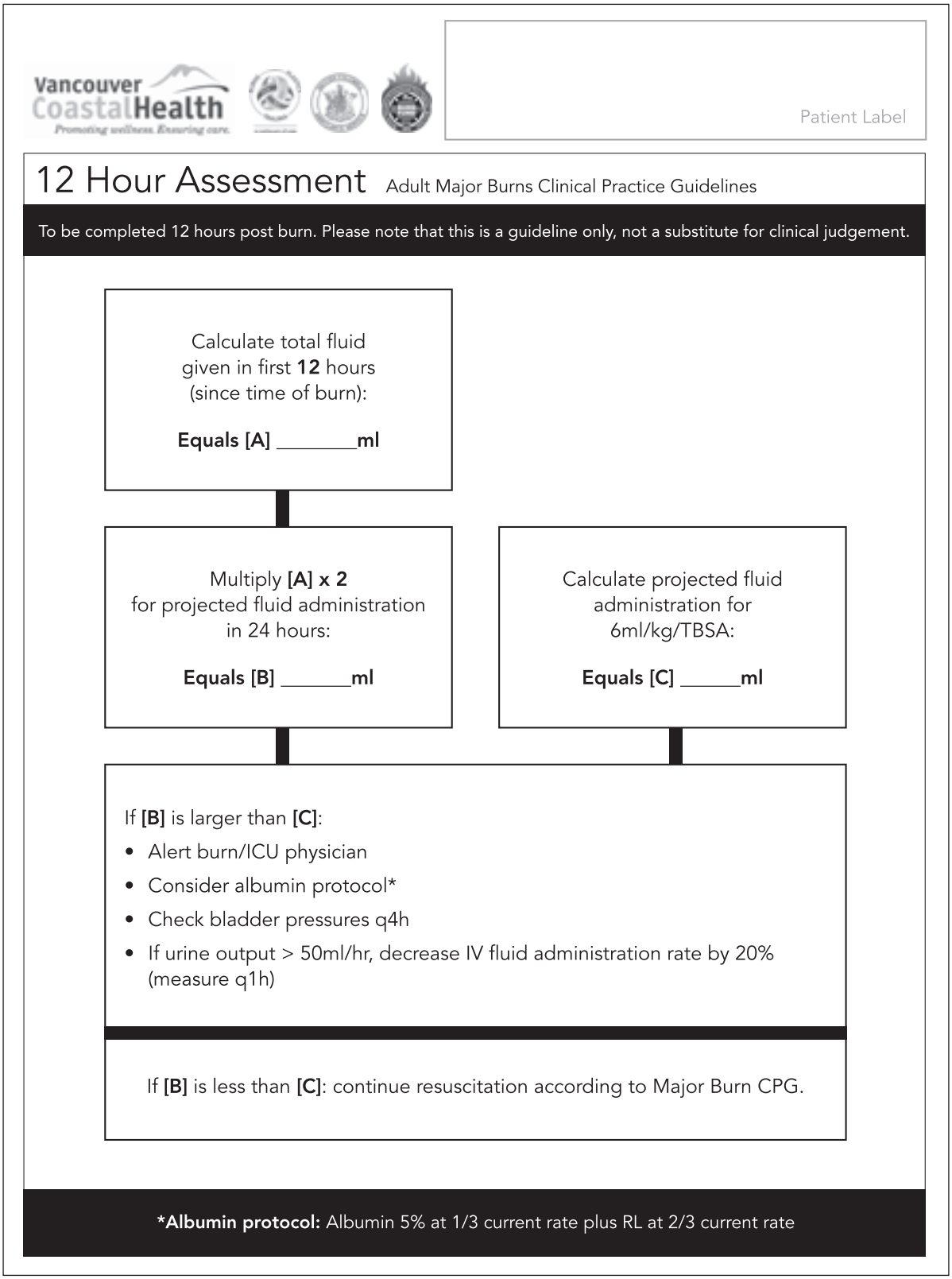
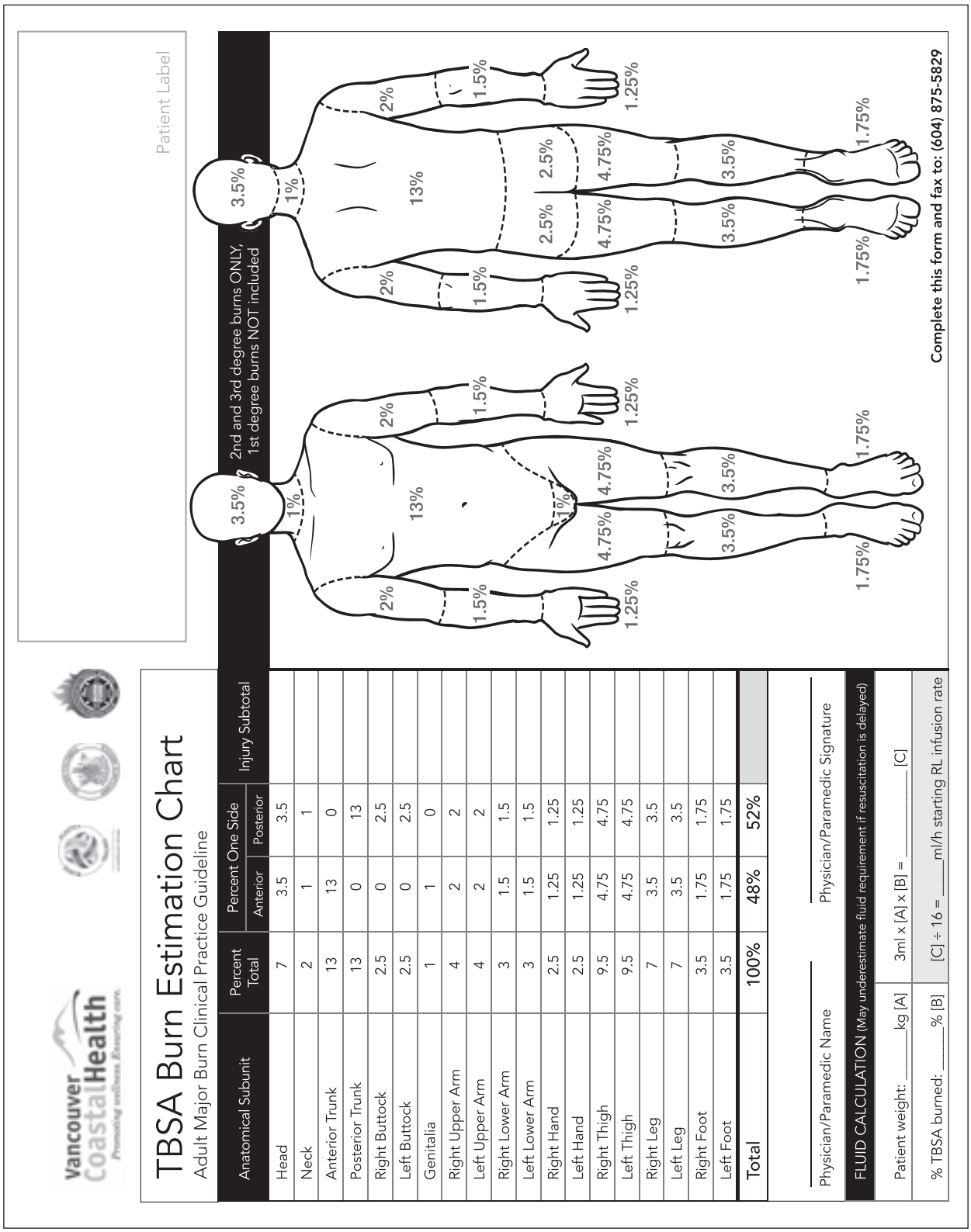


Figure 2. ***12 Hour Assessment.***

This worksheet is designed to assist with early identification of over-resuscitation with fluids.



Anatomical Subunit	Percent Total	Percent One Side		Injury Subtotal
		Anterior	Posterior	
Head	7	3.5	3.5	
Neck	2	1	1	
Anterior Trunk	13	13	0	
Posterior Trunk	13	0	13	
Right Buttock	2.5	0	2.5	
Left Buttock	2.5	0	2.5	
Genitalia	1	1	0	
Right Upper Arm	4	2	2	
Left Upper Arm	4	2	2	
Right Lower Arm	3	1.5	1.5	
Left Lower Arm	3	1.5	1.5	
Right Hand	2.5	1.25	1.25	
Left Hand	2.5	1.25	1.25	
Right Thigh	9.5	4.75	4.75	
Left Thigh	9.5	4.75	4.75	
Right Leg	7	3.5	3.5	
Left Leg	7	3.5	3.5	
Right Foot	3.5	1.75	1.75	
Left Foot	3.5	1.75	1.75	
Total	100%	48%	52%	

FLUID CALCULATION (May underestimate fluid requirement if resuscitation is delayed)

Patient weight: _____kg [A] | 3ml x [A] x [B] = _____ [C]

% TBSA burned: _____% [B] | [C] ÷ 16 = _____ml/h starting RL infusion rate

Figure 3. ***TBSA Burn Estimation Chart.***

This chart is based on the Lund-Browder TBSA assessment chart,[10] 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.

Vancouver Coastal Health
Promoting wellness. Ensuring care.

Patient Label

Resuscitation Flow Sheet Adult Major Burns Clinical Practice Guidelines

Date	Name	PHN
Injury Date + Time	**Initial Treatment Facility**	**Initial Treatment Time**

Pre-Burn Estimations		Estimated Fluid Volume Patient Should Receive		
Weight (kg)	% TBSA	1st 8hrs	2nd 16hrs	Est. Total 24hrs

Tx Site/Team	After Burn	Local Time	Crystalloid	Colloid	**TOTAL**	Urine Output	Lactate	MAP
	1st hr							
	2nd hr							
	3rd hr							
	4th hr							
	5th hr							
	6th hr							
	7th hr							
	8th hr							
	9th hr							
	10th hr							
	11th hr							
	12th hr							
				Total Fluids:		Fluid Balance:		
	13th hr							
	14th hr							
	15th hr							
	16th hr							
	17th hr							
	18th hr							
	19th hr							
	20th hr							
	21st hr							
	22nd hr							
	23rd hr							
	24th hr							
				Total Fluids:		Fluid Balance:		

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.

Vancouver CoastalHealth
Promoting wellness. Ensuring care.

ICU

Sol N. Gregory, MD
David D. Sweet MD FRCP(C)

Monitoring	General Management	Initial Goals
☐ Intravascular arterial blood pressure	☐ HOB ≥ 30°	☐ Urine output minimum 30ml/h maximum 50ml/h
☐ CVC (preferably supradiaphragmatic)	☐ Gastric prophylaxis	☐ Temperature ≥ 37°C
☐ $ScvO_2$ q3h X 24h then R/A	☐ DVT prophylaxis	☐ MAP ≥ 65mmHg
☐ CVP as per ICU protocols	☐ Burn dressings as per Plastic Surgery	☐ $ScvO_2$ ≥ 70%
☐ Lactate q3h X 24-72h	☐ Elevate all burned body parts when possible	☐ Lactate ≤ 4mmol/L
☐ ABGs as per ICU protocols	☐ Start uninterrupted enteric feeds as early as possible (as per Dietitian) unless legitimate concern of splanchnic hypoperfusion or abdominal compartment syndrome	☐ Hgb ≥ 70g/L
☐ Bladder pressures q6h from 12-72h post burn		☐ Plt ≥ 50 *(Actively bleeding or imminently going to OR)*
☐ Increase frequency if pressures ≥ 15mmHg	☐ Fecal containment system for perineal burns as directed by ICU or Burn physician	☐ INR ≤ 1.5 *(Actively bleeding or imminently going to OR)*
☐ For facial burns or inhalational injury: - Consult Ophthalmology - Consider Bronchoscopy *(if suspicion of inhalational injury)*	☐ Attempt to minimize opioid infusion administration and utilize prn opioids as soon as feasible	

Initial Fluid Resuscitation

STEP 1 Calculate initial 24h resuscitation fluid requirements = (3ml of Ringers Lactate)(kg)(% TBSA from Plastics consult) / 24h. ½ of this IVF is administered in the first 8 hours (post burn) and the second ½ 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 rate as above based on urine output.

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

I) **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 until 48 hours post burn.

II) **Watch for signs of Intra-Abdominal Hypertension** (bladder pressure ≥ 15mmHg, increased airway pressures, decreased urine output, hypotension) and extremity compartment syndromes (absent doppler signal or pulses that are diminishing on serial exams q30-60 minutes should prompt consideration of escharotomy)

Recommendations for Hypotension

True hypotension MUST BE correlated with urine output.

If MAP is consistently ≤ 65mmHg and there is evidence of poor end-organ perfusion (urine output ≤ 30ml/hr, lactate ≥ 4mmol/L, $ScvO_2$ ≤ 70%) the following steps are recommended:

I) **Volume Status:** If CVP ≤ 5mmHg or pulse pressure variation ≥ 15mmHg and patient is not breathing spontaneously, administer a fluid bolus of 0.5-1L RL in attempt to improve MAP (it is UNCOMMON to achieve CVP goals of 10-12mmHg in severe burn patients).

II) **Vasopressors:** If MAP is persistently ≤ 65mmHg initiate Levophed at 1-20 ug/min to maintain MAP ≥ 65mmHg (massive burn patients commonly require Levophed 1-5 ug/min due to extensive vasodilatory shock secondary to the massive systemic inflammatory response associated with severe burns).

III) **MAP Goal:** If persistently requiring levophed (1-5ug/min) consider a MAP goal of ≥ 55mmHg as long as urine output ≥ 30ml/hr, $ScvO_2$ ≥ 70% and lactate ≤ 4mmol/L.

IV) **Ca^{2+} 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 q8h) or hypocalcaemia (maintain ionized calcium ≥ 1.1 mmol/L). (1-5)

1. Azzopardi EA, Mcwilliams B, Iyer S, Whitaker IS. Fluid resuscitation in adults with severe burns at risk of secondary abdominal compartment syndrome—An evidence based systematic review. Burns. 2009 Nov 1;35(7):911-20.
2. Ennis JL, Chung KK, Renz EM, Barillo DJ, Albrecht MC, Jones JA, et al. Joint Theater Trauma System implementation of burn resuscitation guidelines improves outcomes in severely burned military casualties. J Trauma. 2008 Feb 1;64(2 Suppl):S146-51; discussion S51-2.
3. Latenser BA. Critical care of the burn patient: the first 48 hours. Critical Care Medicine. 2009 Oct 1;37(10):2819-26.
4. Saffle JIL. The phenomenon of "fluid creep" in acute burn resuscitation. J Burn Care Res. 2007 Jan 1;28(3):382-95.
5. Cartotto R, Zhou A. Fluid creep: the pendulum hasn't swung back yet! J Burn Care Res. 2010 Jan 1;31(4):551-8.

Figure 5. ***ICU.***

This clinical tool for fluid resuscitation and monitoring in the intensive care unit provides step-by-step instructions for management in standard and more complex major burn trauma. Note that some patients may require large fluid resuscitation volumes, or may be hemodynamically unstable and require colloid administration and/or vasoactive medications. Note also that early contact with an on-call burn physician is encouraged.

Continued from page 458

has been positive, and more rigorous analysis of the clinical impact of these CPGs will occur during scheduled quality reviews at 2 and 5 years. Updates in burn medicine will be integrated into the CPGs every 5 years, or more frequently as required. There are some concerns that the changes in fluid management strategies recommended by the CPGs may result in 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.

This information is intended for all levels of care providers and should help reduce variability in fluid resuscitation calculations.

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

1. Baxter CR, Shires T. Physiological response to crystalloid resuscitation of severe burns. Ann N Y Acad Sci 1968; 150:874-894.
2. Alvarado R, Chung KK, Cancio LC, et al. Burn resuscitation. Burns 2009;35:4-14.
3. Chung KK, Blackbourne LH, Wolf SE, et al. Evolution of burn resuscitation in operation Iraqi freedom. J Burn Care Res 2006;27:606-611.
4. Ennis JL, Chung KK, Renz EM, et al. Joint Theater Trauma System implementation of burn resuscitation guidelines improves outcomes in severely burned military casualties. J Trauma 2008;64:S146-151; discussion S51-52.
5. Pruitt BA Jr. Protection from excessive resuscitation: "Pushing the pendulum back." J Trauma 2000;49:567-568.
6. Cartotto R, Zhou A. Fluid creep: The pendulum hasn't swung back yet! J Burn Care Res 2010;31:551-558.
7. Oda J, Yamashita K, Inoue T, et al. Resuscitation fluid volume and abdominal compartment syndrome in patients with major burns. Burns 2006;32:151-154.
8. Saffle JIL. The phenomenon of "fluid creep" in acute burn resuscitation. J Burn Care Res 2007;28:382-395.
9. Latenser BA. Critical care of the burn patient: The first 48 hours. Crit Care Med 2009;37:2819-2826.
10. Miminas DA. Critical evaluation of the Lund and Browder Chart. Wounds UK 2007;3:58-68.
11. Tanaka H, Matsuda T, Miyagantani Y, et al. Reduction of resuscitation fluid volumes in severely burned patients using ascorbic acid administration: A randomized, prospective study. Arch Surg 2000; 135:326-331.
12. Kahn SA, Beers RJ, Lentz CW. Resuscitation after severe burn injury using high-dose ascorbic acid: A retrospective review. J Burn Care Res 2011;32:110-117. BCMJ