**Appendix 1 - Summary of Literature**

1) Bloch, E.C., Hyperthermia resulting from tourniquet application in children. Ann R Coll Surg Engl, 1986. 68(4): p. 193-4.

1. **Authors, year of publication, site**- single center at Duke
2. **Intervention type, duration**- observational 120 min
3. **Study populations/settings-** ASA ½ with halothane/nitrous- GETA, , n- 56-- 3 groups of patients- 32 u/l lower limb, 24 b/l lower limb, 3 14 superficial procedures- complete charts for 32, 24, 14 patients , ages 3 mo to 12 years, wt 6-56 kg
4. **Aims of study**- investigate use of tourniquet in limb surgery with inc in body temp in single instutiont peds study-
5. **Methodology**- measurement of temp every 15 min for 120 min
6. **Outcomes-** mild inc temp over 120 min (largest was 2.8deg) mean inc 1.33 if b/l and 0.71 if unilateral
7. **Important results**- mild elevation in body temp with two hours of anesthesia and limb tourniquets- not sure if it means anything
8. **Critiques of the data-** one way ANOVA and not clear about tourniquet pressures/types

2) Bloch, E.C., et al., Limb tourniquets and central temperature in anesthetized children. Anesth Analg, 1992. 74(4): p. 486-9.

1. **Authors, year of publication, site** – single center
2. **Intervention type, duration**- observational meas of tourniquet 15 b/l 8 u.l and 24 control for 90 minutes
3. **Study populations/settings –** pediatric patients
4. **Aims of study**- investigate use of tourniquet on body temp in surgery
5. **Methodology**- prospective observation x 90 min
6. **Outcomes**- minor inc
7. **Important results**- 1+/-0.6 in u/l and 1.7 +/- 0.6 in bilateral thought to be from infective heat loss from distal skin and from constraint of metabolic heat to the central thermal compartment
8. **Critiques of the data-** again little info on type of tourniquet

3) Brustowicz, R.M., C. Moncorge, and B.V. Koka, Metabolic responses to tourniquet release in children. Anesthesiology, 1987. 67(5): p. 792-4.

1. **Authors, year of publication, site -** single center clinical report from Harvard/Child Boston
2. **Intervention type, duration**- observation of metabolic change after tourniquet relese
3. **Study populations/settings-** mean duration tourniquet 56 (range 20-125)
4. **Aims of study –** measure metabolic changes from tourniquet use
5. **Methodology**- measured labs/ETCo2 5 min before and 1, 5, 15, 30, 60 mn after deflation--
6. **Outcomes**- inc in mean HR by 12 bpm one minute after and dec in ABP by 14, mildrop in ph by 0.05, inc in lactate by 1, mild change in lytes but all within normal range, no change in myoglobin (lactate rises most 30 min after inflaxtion and inc more after release)—not clinically sig
7. **Important results**- none of changes clinically sig
8. **Critiques of the data**- min infor on cuff pressures/types

4) [Budic I](https://www.ncbi.nlm.nih.gov/pubmed/?term=Budic%20I%5BAuthor%5D&cauthor=true&cauthor_uid=21777032)1, [Pavlovic D](https://www.ncbi.nlm.nih.gov/pubmed/?term=Pavlovic%20D%5BAuthor%5D&cauthor=true&cauthor_uid=21777032), [Kocic G](https://www.ncbi.nlm.nih.gov/pubmed/?term=Kocic%20G%5BAuthor%5D&cauthor=true&cauthor_uid=21777032), [Cvetkovic T](https://www.ncbi.nlm.nih.gov/pubmed/?term=Cvetkovic%20T%5BAuthor%5D&cauthor=true&cauthor_uid=21777032), [Simic D](https://www.ncbi.nlm.nih.gov/pubmed/?term=Simic%20D%5BAuthor%5D&cauthor=true&cauthor_uid=21777032), [Basic J](https://www.ncbi.nlm.nih.gov/pubmed/?term=Basic%20J%5BAuthor%5D&cauthor=true&cauthor_uid=21777032), [Zivanovic D](https://www.ncbi.nlm.nih.gov/pubmed/?term=Zivanovic%20D%5BAuthor%5D&cauthor=true&cauthor_uid=21777032).Biomarkers of Oxidative Stressand Endothelial Dysfunction After Tourniquet Release in Children. Physiol Res. 2011;60 Suppl 1:S137-45. Epub 2011 Jul 19.

1. **Authors, year of publication, site**: As above, July 19, 2011
2. **Intervention type, duration:** measurement of plasma xanthine oxidase levels 5 and 20 minutes after tourniquet release.
3. **Study populations/settings**: 45 patients ASA I or II, 8 to 17 years of age, undergoing orthopedic procedures that required bloodless limb surgery. Children were randomized to sevoflurane (n=15), propofol (n=15) or peripheral nerve block (n=15) group.
4. **Aims of study:** Investigate possible effect of different anesthesia techniques on oxidative stress and endothelial dysfunction connected with I/R injury during extremity operations at children's age.
5. **Methodology:** Randomized uncontrolled trial
6. **Outcomes:** This study demonstrates that total intravenous anesthesia with propofol and regional anesthesia techniques provide better antioxidant defense and reduce endothelial dysfunction than general inhalational anesthesia with sevoflurane during tourniquet application.
7. **Important results:** There is less oxidative stress when tourniquets are released in patients who’ve had regional anesthesia and profofol than for those who’ve had general anesthesia with sevofluane.
8. **Critiques of the data.** Small comparison numbers. Outcomes of study are not generalizable: patients were all orthopedic surgery patients who were undergoing surgery.

5) [Dua A](https://www.ncbi.nlm.nih.gov/pubmed/?term=Dua%20A%5BAuthor%5D&cauthor=true&cauthor_uid=23683379)1, [Via KC](https://www.ncbi.nlm.nih.gov/pubmed/?term=Via%20KC%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Kreishman P](https://www.ncbi.nlm.nih.gov/pubmed/?term=Kreishman%20P%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Kragh JF Jr](https://www.ncbi.nlm.nih.gov/pubmed/?term=Kragh%20JF%20Jr%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Spinella PC](https://www.ncbi.nlm.nih.gov/pubmed/?term=Spinella%20PC%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Patel B](https://www.ncbi.nlm.nih.gov/pubmed/?term=Patel%20B%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Gillespie DL](https://www.ncbi.nlm.nih.gov/pubmed/?term=Gillespie%20DL%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Mahoney P](https://www.ncbi.nlm.nih.gov/pubmed/?term=Mahoney%20P%5BAuthor%5D&cauthor=true&cauthor_uid=23683379), [Fox CJ](https://www.ncbi.nlm.nih.gov/pubmed/?term=Fox%20CJ%5BAuthor%5D&cauthor=true&cauthor_uid=23683379). Early management of pediatric vascular injuries through humanitarian surgical care during U.S. military operations. J Vasc Surg. 2013 Sep;58(3):695-700. doi: 10.1016/j.jvs.2013.02.034. Epub 2013 May 14.

1. **Authors, year of publication, site:** U.S. military combat support hospital in Baghdad, Iraq.2013
2. **Intervention type, duration:** Descriptive study only
3. **Study populations/settings:** Twenty-five children, median age 14 years (range, 5-17 years), median weight 48 kg (range, 15-80 kg) sustained 18 (72%) blast and 7 (28%) gunshot wounds. The mean Injury Severity Score was 25 +/- 16.2.
4. **Aims of study:** Describe the types of pediatric vascular injuries and their management at
5. **Methodology:** Retrospective cross-sectional study. Joint Theater Trauma Registry (JTTR) records retro-spectively evaluated consecutive pediatric (age<18 years) vascular injuries managed in a single military hospital in Baghdad, Iraq between April 2006 and August 2008.
6. **Outcomes:** 4 patients (16%) had amputations. Upon emergency department arrival, the mean physiological parameters noted patients to be tachycardic (136 +/-29 bpm), hypotensive (109/63 +/-29/19 mm Hg), and acidemic. The vast majority (21; 84%) of all children received blood products. **Two patients** had tourniquets applied and had limbs amputated.
7. **Important results:** This is the largest reported wartime series to demonstrate in children that damage control resuscitation despite high injury severity permits simultaneous limb salvage.
8. **Critiques of the data:** Not much value for a guideline about tourniquet use.

6) [Eidelman M](https://www.ncbi.nlm.nih.gov/pubmed/?term=Eidelman%20M%5BAuthor%5D&cauthor=true&cauthor_uid=16891968)1, [Katzman A](https://www.ncbi.nlm.nih.gov/pubmed/?term=Katzman%20A%5BAuthor%5D&cauthor=true&cauthor_uid=16891968), [Bialik V](https://www.ncbi.nlm.nih.gov/pubmed/?term=Bialik%20V%5BAuthor%5D&cauthor=true&cauthor_uid=16891968). A novel elastic exsanguination tourniquet as an alternative to the pneumatic cuff in pediatric orthopedic limb surgery. J Pediatr Orthop B. 2006 Sep;15(5):379-84.

1. **Authors, year of publication, site:** 2006 Haifa,Israel
2. **Intervention type, duration:** prospective use of the S-Mart tourniquet use for limb surgery in place of pneumatic exsanguination device standard, with no control.
3. **Study populations/settings:** Only patients with limb dimensions within the range specified by the manufacturer (circumference > 24 cm) were included. Exclusion criteria included patients with grossly misaligned and unstable limb fracture or disloca-tion, deep vein thrombosis, severe skin disorders and procedures with tourniquet time expected to last > 2 hours
4. **Aims of study:** Evaluate criteria of the S-mart tourniquet device:
   1. Ease of application
   2. Time of application
   3. Tourniquet position on the limb
   4. Quality of exsanguination – bleeding upon firstincision
   5. Prevention of subsequent bleeding – throughout the entire procedure
   6. Interference with surgical site/procedure
   7. Limb/joint mobility distal and proximal to thetourniquet ring
   8. Quality of stockinet
   9. Ease of removal
   10. Surgical complications
5. **Methodology:** Observational trial
6. **Outcomes:** The overall rating of the new device is high and we feel that it is a very useful contribution to clinical practice. The device was sterile, kept the surgical field free of blood, was easy to use, and didn’t damage the underlying skin.
7. **Important results:** As above.
8. **Critiques of the data:** tourniquet used in operative theater rather than a prehospital ‘stop the bleed’ application.

7) [Goodarzi M](https://www.ncbi.nlm.nih.gov/pubmed/?term=Goodarzi%20M%5BAuthor%5D&cauthor=true&cauthor_uid=9150013)1, [Shier NH](https://www.ncbi.nlm.nih.gov/pubmed/?term=Shier%20NH%5BAuthor%5D&cauthor=true&cauthor_uid=9150013), [Grogan DP](https://www.ncbi.nlm.nih.gov/pubmed/?term=Grogan%20DP%5BAuthor%5D&cauthor=true&cauthor_uid=9150013). **Does sympathetic blockade prevent the physiologic changes associated with tourniquet use in children?** Pediatr Orthop. 1997 May-Jun;17(3):289-92.

1. **Authors:** 1997, Shriners Children’s Hospital Tampa
2. **Intervention type, duration:** RCT
3. **Study populations/settings:** 40 patients (9 months to 10 years, mean age 6.5 years) were randomized into two groups of 20, the control group had nitrous/narcotic, the intervention group had epidural bupivacaine sympathetic blockade. A thermographic study was used to confirm sympathetic blockade. Data collected every 15 minutes till tourniquet deflated.
4. **Aims of study:** Determine if sympathetic blockade prevents post-tourniquet syndrome (e.g. neurological dysfunction, swelling)
5. **Methodology:** Intervention group had epidural bupivacaine, control had nitrous/narcotic only.
6. **Outcomes:** the intervention group had fewer deviations in vital signs and tolerated the blockade well.
7. **Important results:** Blockade blunts the physiologic changes associated with tourniquet use.
8. **Critiques of the data:** Would need a different route, sympathetic drive may promote survival in some trauma patients, so this kind of blockade may be impractical.

8) Goodarzi M, Shier NH, Ogden JA. [**Physiologic** **changes** during **tourniquet** use in **children**.](https://www.ncbi.nlm.nih.gov/pubmed/1613097) J Pediatr Orthop. 1992 Jul-Aug;12(4):510-3.

1. **Authors, year of publication, site:** 1992. Shriner’s Children’s Hospital.
2. **Intervention type, duration:** hemodynamic and metabolic changes associated with unilateral tourniquet use in children.
3. **Study populations/settings:** 30 children undergoing orthopedic surgery, age 8-14.
4. Aims of study: Determine the hemodynamic and metabolic changes associated with unilateral tourniquet use in children.
5. **Methodology:** Compared the duration of tourniquet inflation for lower extremity surgery with regards to: temperature, pulse, lactate and end tidal CO2 before tourniquet inflation and before tourniquet deflation.
6. **Outcomes:** Lactate, EtCO2 and temperature all increased with tourniquet application, particularly after 70 minutes.
7. **Important results:** hyperthermia, hypercarbia (relative) and lactic acidosis occurred with prolonged tourniquet inflation.
8. **Critiques of the data:** No comment about pulse, may not have been significant.

9) King DR, van der Wilden G, Kragh JF Jr, Blackbourne LH. Forward assessment of 79 prehospital battlefield tourniquets used in the current war. J Spec Oper Med. 2012 Winter;12(4):33-8.

1. **Authors, year of publication, site** – 2012, Afghanistan (war casualties presenting to forward surgical team)
2. **Intervention type, duration** – Combat tourniquet application form 8/2011-11/2011
3. **Study populations/settings** – War casualties, 79 tourniquets on 65 limbs, 54 pts
4. **Aims of study** – Review of tourniquet use, multiple techniques, effectiveness
5. **Methodology** – Retrospective review
6. **Outcomes** – 83% of limbs with palpable distal pulses, need for reapplication of tourniquets, conversion of venous to arterial tourniquet frequent
7. **Important results** – Continued need of re-evaluation after application of tourniquet. Only 17/65 limbs with tourniquets had vascular injury! 100% of injuries presented with tourniquet.
8. **Critiques of the data** – retrospective case series, single site, no ages of patients documented in study, unclear if any children included

10) King DR, Larentzakis A, Ramly EP; Boston Trauma Collaborative. Tourniquet use at the Boston Marathon bombing: Lost in translation. J Trauma Acute Care Surg. 2015 Mar;78(3):594-9.

1. **Authors, year of publication, site** – 2015, Boston marathon bombing
2. **Intervention type, duration** – Improvised tourniquets, single event
3. **Study populations/settings** – Age 15-71 years
4. **Aims of study** – Evaluate tourniquet use in patients with extremity injury resulting from Boston Marathon bombing
5. **Methodology** – Retrospective review of database detailing injuries from Boston Marathon bombings treated by all Level 1 Boston trauma centers
6. **Outcomes** – 66 patients with extremity injury, only 27 tourniquets (16/17 traumatic amputations, 5/12 lower extremity major vascular injuries, 6 major soft tissue injury)
7. **Important results** – Majority of injuries not treated with tourniquets, all improvised tourniquets, many non-hemostatic tourniquet. Need for extension of military tourniquet protocols with commercially available tourniquets in civilian practice, and more liberal tourniquet use
8. **Critiques of the data** – small sample size, retrospective case series, single event

11) Kragh, J.F., Jr., et al., Survey of trauma registry data on tourniquet use in pediatric war casualties. Pediatr Emerg Care, 2012. 28(12): p. 1361-5.

1. **Authors, year of publication, site** – 2012, 88 pediatric patients
2. **Intervention type, duration** –
3. **Study populations/settings** – 4-17 years old, average 11
4. **Aims of study** – Evaluate emergency tourniquet use in children war casualties
5. **Methodology** – Retrospective review of war casualty trauma registry 2003-2009
6. **Outcomes** – 93% survival rate. Commercially available tourniquets used in soldiers were effective for children
7. **Important results** – Similar to adults, effectiveness of technique, ? improved overall pediatric survival in war time resulting from tourniquet usage
8. **Critiques of the data** – retrospective review, trauma registry, unclear indication of tourniquets in every case

12) Kragh JF Jr, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, Holcomb JB. Survival with emergency tourniquet use to stop bleeding in major limb trauma. Ann Surg. 2009 Jan;249(1):1-7.

1. **Authors, year of publication, site** – 2009,
2. **Intervention type, duration** – Combat tourniquet use, 3/2006 – 10/2006
3. **Study populations/settings** – Combat casualties, age 4-70 years, 9 children (232 total patients)
4. **Aims of study** – Effectiveness of emergency tourniquet use in combat setting
5. **Methodology** – Prospective observational study, cohort and subgroup analtisis
6. **Outcomes** – Improved survival with tourniquets
7. **Important results** – tourniquets save lives especially in setting of shock, few complications from tourniquet use – benefits far outweigh risks
8. **Critiques of the data** – combat setting, mixed population with few children

13) Lieberman, J.R., L.T. Staheli, and M.C. Dales, Tourniquet pressures on pediatric patients: a clinical study. Orthopedics, 1997. 20(12): p. 1143-7.

1. **Authors, year of publication, site** – 1997
2. **Intervention type, duration** – observation of hemostasis with tourniquet pressure in 29 surgical cases
3. **Study populations/settings** – operating room
4. **Aims of study** – determine appropriate tourniquet pressure used in extremity surgeries in children
5. **Methodology** – prospective, observational study
6. **Outcomes** – Setting tourniquet pressure to 50 mmhg over occlusion pressure resulting in 86/5 with adequate hemostasis
7. **Important results** – Lower tourniquet pressures may be effective in data
8. **Critiques of the data** – Small series, no comparison group

14) Lynn, A. M., Fischer, T., Brandford, H. G., & Pendergrass, T. W. (1986). Systemic responses to tourniquet release in children. *Anesth Analg, 65*(8), 865-872.

1. **Authors, year of publication, site** – single-center prospective observational study, U Washington
2. **Intervention type, duration** – observation of metabolic changes after tourniquet release, 15 children (8 unilateral, 7 bilateral)
3. **Study populations/settings** – 6mo – 15 yr, elective orthopedic cases
4. **Aims of study** – document lactic acidosis as a function of tourniquet time, with physiologic compensation
5. **Methodology** – ABG with lactate and VS measured prior to deflation and at 1, 3, 5 and 10 min after deflation
6. **Outcomes** – BP decrease 8-10 mmHg, HR stable, linear increase in arterial lactate as a function of tourniquet time
7. **Important results** – recommend controlled ventilation during tourniquet release to correct met acidosis, larger increases in lactate (>1.5 mol/l) reported with tourniquet times > 75 min, acidosis commonly takes > 10 min to correct
8. **Critiques of the data** – small sample, single institution, healthy subjects at baseline

15) Reilly, C. W., McEwen, J. A., Leveille, L., Perdios, A., & Mulpuri, K. (2009). Minimizing tourniquet pressure in pediatric anterior cruciate ligament reconstructive surgery: a blinded, prospective randomized controlled trial. *J Pediatr Orthop, 29*(3), 275-280.

1. **Authors, year of publication, site** – single institution study at University of British Columbia
2. **Intervention type, duration** – prospective randomized controlled trial over 1 year
3. **Study populations/settings** – 21 children, age 10-17y, elective orthopedic cases
4. **Aims of study** – investigate use of limb occlusion pressure in wide tourniquets as alternative to standardized pressure, 300 mmHg
5. **Methodology** – ½ randomized to control (300 mmHg) and ½ randomized to limb occlusion pressure for ACL repairs. Then visual analog score of adequacy of surgical field and cuff pressures compared for control and protocol groups
6. **Outcomes** – measurement of limb occlusion pressure with wider cuff allowed for effective cuff pressure of 150 mmHg compared to 300 mmHg without significant difference in halt of blood flow
7. **Important results –** table of recommendations for pediatric tourniquet use in the elective setting: Esmarch exsanguination, use limb occlusion pressure + safety margin (based on SBP), use wide cuff, skin protectant sleeve, minimize tourniquet time
8. **Critiques of the data** – poor evidence that lower tourniquet pressure is safer or offers benefits, did not meet self-defined sample size to achieve desired power

16) Sokol, K. K., Black, G. E., Azarow, K. S., Long, W., Martin, M. J., & Eckert, M. J. (2015). Prehospital interventions in severely injured pediatric patients: Rethinking the ABCs. *J Trauma Acute Care Surg, 79*(6), 983-989; discussion 989-990.

1. **Authors, year of publication, site** – single institution retrospective review of military base in Afghanistan performed by clinicians now operating out of PNW
2. **Intervention type, duration** – retrospective review of DoD trauma registry of pediatric interventions performed at Camp Bastion from 2004-2012
3. **Study populations/settings**  -- pediatric (age < 18y) trauma patients, Afghanistan
4. **Aims of study** – define epidemiology and outcomes related to pre-hospital interventions for problems associated with ABCs
5. **Methodology** – reviewed 766 pediatric trauma patients over 8 years, sorted by pre-hospital interventions, measured VS, basic lab values, resuscitation required and mortality
6. **Outcomes** – reduction of PRBCs (4.7U vs 15U) and IVF (0.7L vs 3.0L) used for resuscitation in subjects where a tourniquet/hemostatic dressing was employed. No statistical significance in mortality although trend towards decrease with tourniquets
7. **Important results** – tourniquet use can dramatically decrease resuscitation fluid requirements and trend towards decreasing mortality in pediatric population
8. **Critiques of the data** – single institution, retrospective, 38% of tourniquets/hemostatic dressing without documented injury, only 66% of patients with indication received intervention

17) Tredwell, S. J., Wilmink, M., Inkpen, K., & McEwen, J. A. (2001). Pediatric tourniquets: analysis of cuff and limb interface, current practice, and guidelines for use. *J Pediatr Orthop, 21*(5), 671-676.

1. **Authors, year of publication, site** – University of British Columbia, North American survey
2. **Intervention type, duration** – review of literature, survey of US/Canadian pediatric surgeons, clinical model of skin wrinkling with tourniquet, clay used
3. **Study populations/settings** – questionnaire sent to pediatric orthopedic surgeons in North America
4. **Aims of study** – determine current clinical practice of pediatric tourniquet use, define most common complications, develop practice guideline to reduce cutaneous complications
5. **Methodology** – survey of tourniquet use, brand, underlying protective device, method for determining cuff pressure, complications experienced (blood in surgical field, soft tissue, nerve, muscle)
6. **Outcomes** – Complication distribution: soft tissue injuries 31%, nerve injuries 21%, muscle injuries 12% -- total incidence 0.4-1.4%?
7. **Important results** – Delfi pediatric cuff with limb protection sleeve causes least skin deformity, theoretically suggests least incidence of soft tissue injury. Proposed guidelines for tourniquet use: wide cuff, inflate to limb occlusion pressure + 50 mmHg, use limb protection sleeve, exsanguinate with Esmarch type sleeve, minimize tourniquet time.
8. **Critiques of the data** – poor descriptive statistics, odd measurement of skin deformation model, offers little information about correlation between any variables (padding, cuff pressure, etc.) and incidence of complications, survey only

18) Villamaria, C. Y., Morrison, J. J., Fitzpatrick, C. M., Cannon, J. W., & Rasmussen, T. E. (2014). Wartime vascular injuries in the pediatric population of Iraq and Afghanistan: 2002-2011. *J Pediatr Surg, 49*(3), 428-432.

1. **Authors, year of publication, site** – multi institution retrospective review of pediatric vascular trauma, performed by US Army Institute of Surgical Research
2. **Intervention type, duration --** retrospective review of DoD trauma registry of pediatric vascular injuries treated at US military hospitals in Iraq and Afghanistan from 2002-2011
3. **Study populations/settings** – pediatric (<18y) trauma patients, in military Role III hospitals, Iraq and Afghanistan
4. **Aims of study** – characterize pediatric vascular trauma, pattern of injury, management strategies and outcomes in the wars in Iraq and Afghanistan
5. **Methodology** – demographics, mechanism, vessel injured, treatment modalities, ISS, outcomes collected on all ped vascular injuries
6. **Outcomes** – 6 tourniquets applied in 70 LE vascular injuries: 1 death from concomitant brain injury, 3 ultimately required amputation. No tourniquet complications observed.
7. **Important results** – tourniquet use limited in wartime extremity vascular injury, but not associated with complications, although high rate of amputation despite tourniquet use in this population
8. **Critiques of the data** – minimal data on pediatric tourniquet use