ARC SAC SCIENTIFIC REVIEW
Burn Cooling

Questions to be addressed:

Among adults and children with acute thermal burns, does the use of one cooling modality and duration, compared with another, cause a change in clinical outcomes including pain, depth or size of burn, need for hospitalization, duration of hospital stay, or other?

Introduction/Overview:

A SAC Answer on this topic in June 2019, identified a moderate amount of evidence regarding duration of cooling. An ILCOR (International Liaison Committee on Resuscitation) review on the same topic in 2015 concluded that studies evaluating direction of cooling were primarily animal (pig) studies, which were not included in GRADE analysis. They concluded that a burn treatment should be to "cool thermal burns with cool or cold potable water as soon as possible and for at least 10 minutes. If cool or cold water is not available, a clean cool or cold, but not freezing compress can be useful as a substitute for cooling thermal burns. Care should be taken to monitor for hypothermia when cooling large burns." The SAC Answer from 6-15-19 identified 8 studies on this topic since the 2015 ILCOR publication and is now converted to a Scientific Review.

Search Strategy and Literature Search Performed

Key Words Used

Searched on: 03/20/2019

PubMed
#1 Search Search "Burns/therapy"[Majr] AND (cool or cold or Cooling OR Cooling Agents OR Passive Cooling) Filters: published in the last 5 years; Humans; English =33

#2 Search Search "Burns/therapy"[MAJR] and ("First Aid/methods"[Mesh] OR "First Aid/standards"[Mesh] OR "First Aid/therapy"[Mesh]) Filters: published in the last 5 years; Humans; English =24

#3 Search ((cool or cold or Cooling OR Cooling Agents OR Passive Cooling)) AND ((("First Aid/methods"[Mesh] OR "First Aid/standards"[Mesh] OR "First Aid/therapy"[Mesh]))) Filters: published in the last 5 years; English =12

Inclusion Criteria (time period, type of articles and journals, language, methodology)

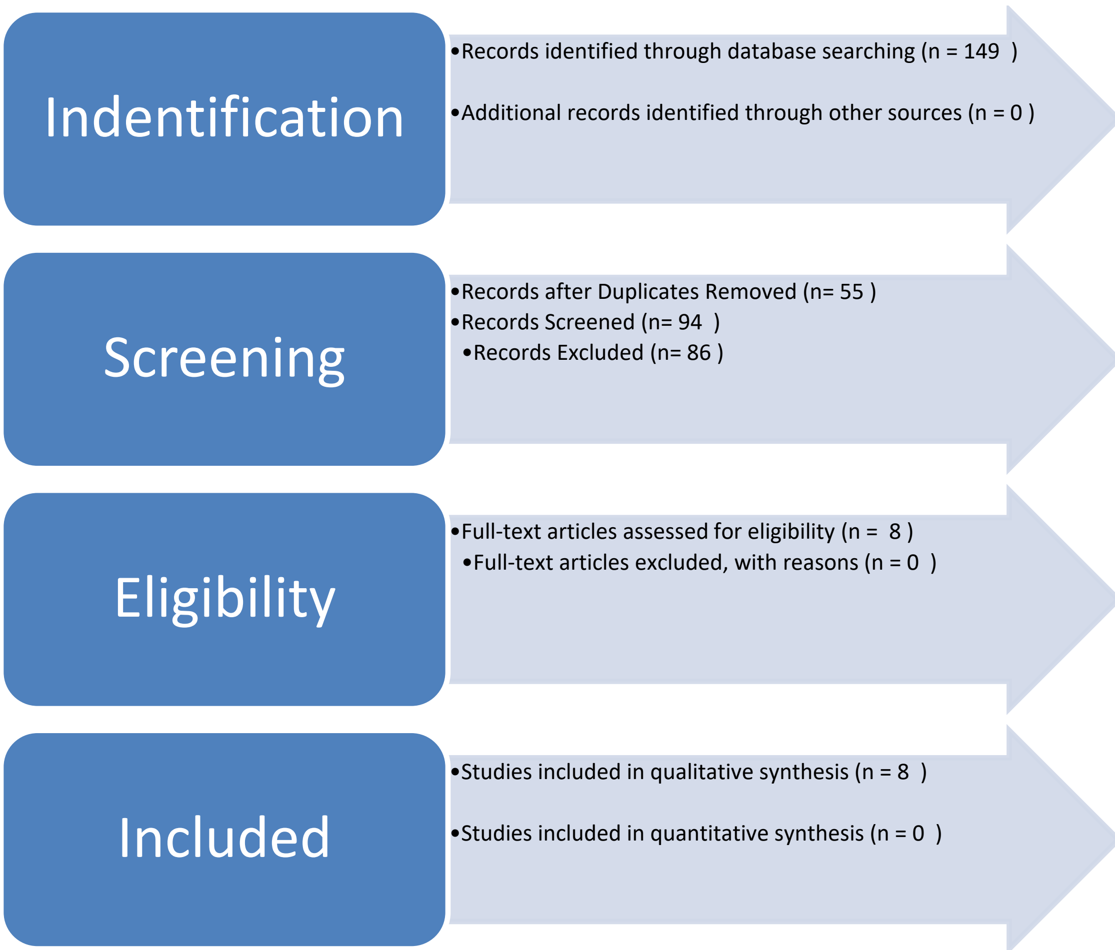
Last 5 years, English

Exclusion Criteria (only human studies, foreign language, etc…)

Foreign languages

Databases Searched and Additional Methods Used (references of articles, texts, contact with authors, etc...)

PubMed



Scientific Foundation:

Until recently, the literature has been sparse regarding whether first aid burn cooling improves outcomes. An ILCOR (International Liaison Committee on Resuscitation) review on this same topic in 2015 noted that studies identified evaluating duration of cooling were primarily animal (pig) studies, which were not included in GRADE analysis[1]. ILCOR's review found no evidence that cooling improves pain, very-low-quality evidence it may decrease burn depth, very-low-quality evidence that it may decrease admission rates and hospital length of stay but did not affect need for advanced care. Their overall recommendation was: first aid providers should actively cool thermal burns. They noted that results from studies included suggested a minimum of 10 minutes of cooling, but they could not recommend a specific temperature or method of cooling. With the ILCOR summary from 2015 as the starting point, the last 5 years of literature was searched to determine outcomes regarding burn cooling.

This review identified 2 randomized control trials (RCT), 4 observational cohort (2 prospective, 2 retrospective), and 2 statistical modeling studies that have been published in the last 5 years relevant to this question. The first RCT was unblinded and looked at acute effects of local cold therapy on superficial burns. They found very transient improvements in microcirculation, edema formation, and histomorphology but cold therapy was ineffective across all measured outcomes after the 30-minute mark.[2] The second RCT evaluated a comparison of three different cooling methods. They compared 20 minutes of cool tap water and two commercial burn dressing products that contain tea tree oil (Burnshield and Burn Cool Spray). All three methods were found to improve pain scores. The cool tap water was able to cool the skin significantly more than the burn dressings. They also found a correlation between temperature of tap water and pain scores.[3]

There were two statistical model studies: one estimating the time and temperature relationship that would cause deep-partial thickness burns (second degree burns) and the other analyzing skin injury from hot spills onto various forms of clothing. The former study found that cooling with tap water increased exposure duration and temperature required to cause deeper burns. For example: if exposed to a 200-degree F scald, second degree burns would develop after 4.6 seconds exposure compared to 7.2 seconds exposure if scald was treated with cool running tap water.[3] The latter study was able to highlight the importance of clothing removal as fast as possible, recommending within the first 2-3 seconds. The thickness of the clothing, skin thickness, and temperature of the water correlated with time to more severe injuries.[5]

As for the observational studies, there were four studies found. The first evaluated 168 Lagos, Nigeria patients prospectively. This study supports cool running water: there were lower complications rates, decreased deep burn percentages, and less need for skin grafting. Surprisingly though, they did find a slightly higher mortality rate in the water lavage group.[6] The second study retrospectively evaluated scald burns in 730 children younger than 14 that required hospitalization in an Australia and New Zealand burn registry. This study as well supports burn cooling. They found shorter hospital length of stay but no difference in need for surgery. The authors highlighted need for better first aid education as only 1/5 of patients received adequate burn cooling (20 minutes of cool running water) despite almost 90% receiving some form of prehospital cooling. The data from this study recommends targeting prevention programs aimed at children aged 0-2 years old (median age of cohort was 2 years old with 70% of total study population between 0-2 years).[7] The third study analyzed 2320 patients retrospectively from that same Australia and New Zealand burn registry, this time for ages greater than 16. The study found 13% reduction in skin grafting, 48% reduction in ICU admission, and 18% reduction in hospital length of stay when adequate burn cooling (20 minutes of cool running water) was provided. It also showed a dose-response relationship with length of cooling, with benefit anywhere from 10 minutes to 40 minutes. Longer duration greater than 40 minutes may cause harm.[8] The final study evaluated 4918 patients prospectively for clinical outcomes after burn first aid. They found a statistically significant reduction in burn depth but not reduction in total body surface area (TBSA) or need for grafting. Those that were grafted required 15% less area grafted if they received adequate first aid. Those receiving adequate first aid had 10% reduction in recovery time.[9]

Overall these studies did show benefit from burn cooling. They all used the standard of 20 minutes cool running water within the first 3 hours of injury as their definition of “adequate first aid”. As discussed above, these studies are overall a low-certainty evidence with some mixed results. Nevertheless, the trend of these papers does show benefit to burn cooling. Despite lack of high certainty human studies, standard first aid treatment of thermal burns includes immediately removal of overlying clothing and jewelry and providing cool running water for a minimum of 20 minutes (within the first 3-hours post injury) to the burn.

In summary, evidence from this review supports recommendations that patients who sustain thermal burns should have overlying clothing and jewelry removed and cooling immediately by applying cool running water to the burn for a minimum of 10 minutes, ideally 20 minutes. If cool or cold water is not available, a clean cool or cold, but not freezing compress can be useful as a substitute for cooling thermal burns. There may be benefit in applying cool water up to 3 hours after the injury. Care should be taken to monitor for hypothermia when cooling large burns. There is also evidence of potential harm due to risk of hypothermia, especially in small children, from cooling beyond 40 minutes.

Recommendations:

Standard:

- Monitor for hypothermia when cooling large burns or burns in small children. (Level 5)
- Avoid cooling beyond 40 minutes due to risk of hypothermia. (Level 2b)
- Do not use ice to cool a burn, including an ice pack or bag, due to a risk of worsening the injury. (Level 4)

Guideline:

- Patients who sustain thermal burns should have overlying clothing and jewelry removed (Level 2a, 2b)
- Begin immediate cooling of thermal burns, preferably with cool running water applied to the burn for a minimum of 10 minutes, ideally 20 minutes. (Level 2a, 2b)

Option:

- There may be benefit in cooling a burn up to 3 hours after the injury. (Level 5)
- If cool or cold water is not available, a clean cool or cold compress or cold pack can be used as a substitute to cool thermal burns. (Level 5)

Knowledge Gaps and Future Research:

There is still limited, weak confidence evidence in duration of cooling as well as any other methods that do not require copious amounts of fresh water. Future studies should focus on comparing outcomes for various cooling times as well as investigation into alternatives to cool running water.

Implications for ARC Programs:

The results of this review should be posted on Instructors Corner immediately and incorporated into the First Aid Participants manual with the upcoming revision.

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Summary of Key Articles/Literature Found and Level of Evidence/Bibliography:

Author	Full Citation	Summary of Article (provide a brief summary of what the article adds to this review including which question(s) it supports, refutes or is neutral)	Methodology	Bias Assessment	Key results and magnitude of results	Support, Neutral or Oppose Question	Level of Evidence
Singletary et al	Part 15: first aid: 2015 American Heart Association and American Red Cross Guidelines Update for First Aid. *Circulation.* 2015;132(suppl 2): S574–S589	Provides the starting point for this scientific review, it established a minimum cooling time of 10 minutes.	Systematic review	Low	Found no evidence that cooling improves pain, very-low-quality evidence it may decrease burn depth, very-low-quality evidence that it may decrease admission rates and hospital length of stay but did not affect need for advanced care. Their overall recommendation was: first aid providers should actively cool thermal burns. They noted that results from studies included suggested a minimum of 10 minutes of cooling, but they could not recommend a specific temperature or method of cooling.	Support	5
B. Altintas et al	Acute effects of local cold therapy in superficial burns on pain, in vivo microcirculation, edema formation, and histomorphology. Burns. 40:5;915-21. 2014	Analyzed superficial burns to 12 participant's hands then used one hand as control and the other was cooled for 20 minutes in 12-degree Celsius water bath. No significant	Unblinded, randomized control trial	High	Pain was improved in cooling group through the 15-minute mark but was no different at 30 minutes. Epidermal thickness, granular cell size, individual blood cell flow, functional capillary density all had no significant difference at the 30-minute mark. Local cold therapy influences microcirculation, edema formation, and histomorphology	Neutral	2a

		difference at the 30-minute mark for any of the objective measurements. Local tissue effects and pain levels are only transiently affected by local cold-water therapy.			significantly, however, observed acute effects are transient and become ineffective beyond 30 minutes compared to control.		
Cho and Choi	Comparison of three cooling methods for burn patients: A randomized clinical trial. Burns. 43:3;502-8. 2017	96 patients randomized to receive 20 minutes of tap water 24-27 degrees Celsius), Burnshield, or Burn Cool Spray (both trademarked treatments containing tea tree oil) with the thought that running tap water cannot be performed in some locations (airplane, ambulance, etc) and that running tap water consumes a lot of water (upwards of 120-240L over 20 minutes). They sought to evaluate these commercially available treatments compared to the standard recommendation of tap water.	Unblinded, randomized control trial	High	96 patients enrolled. All three methods were able to significantly reduce pain levels on the VAS pain score but pain levels were still relatively high after treatment in all three groups. Tap water was able to significantly reduce skin temperature compared to the other two methods. The temperature of the tap water correlated with reduction in the skin surface temperature and VAS pain score.	Supports	2a
Abraham et al	Estimating the time and temperature relationship for causation of deep-partial thickness skin burns. Burns. 41:8;1714-47. 2015	Used statistical models to help predict duration and temperature from water scald burns required to cause various depth of	Statistical model	Unclear	With exposure to 200 degree F scalds, exposure time required to cause deep partial thickness burns was 4.6 seconds compared to 7.2 seconds if cooled by tap water. This difference was maintained throughout various other scald temperatures.	Supports	4E

		burn. It was able to show that cooling with tap water both increased the exposure duration and temperature needed to cause deeper burns. Given the wide variety of circumstances of a scald, no standard model can define all the variables.			Shorter and lower temperature exposures were needed to cause deep partial thickness burns in children, due to 70% thickness of skin compared to adults.		
Log, T.	Modeling of Skin Injury From Hot Spills on Clothing. Int J Environ Res Public Health. 14;11.2017	Highlighted importance of clothing removal as fast as possible, ideally within the first few seconds of exposure. The thickness of clothing, epidermal thickness, and temperature of the water correlated with time to more severity of injuries. They recommend 20-30 minutes of tepid water cooling.	Statistical model	Unclear	The thickness of clothing, epidermal thickness, and temperature of the water correlated with time to more severity of injuries.	Supports	4E
Fadeyibi et al	Practice of first aid in burn related injuries in a developing country. Burns. 41:6;1322-32	An observational study of the types of first aid provided for burns and evaluate how the application of water influenced length of hospital stay, complications, and mortality rate in Lagos, Nigeria. They enrolled 168 patients. It supports the use of water lavage, with lower	Prospective observational cohort study	Low	Water lavage provided to 36.6% of fire-related burns, 27.5% of scalds, and 14.3% of other causes. Home versus other did not show significant difference in rate of water lavage. Overall water lavage used in 29.2% of cases. Significantly higher proportion, 35.3% of patients that had no water first aid had complications versus 18.4% complication rate for water lavage. Higher proportion not receiving water lavage had wounds of greater depth (77.3% versus 65%). No difference in need for escharotomies but there was	Supports	2b

		complication rates and less area developing into deep burns. Mortality rate was higher in the water lavage group, study authors suspected small sample size and higher rates of petroleum burns in the water lavage group as the cause for this difference. Other limitations included: unclear water source, duration of lavage, or temperature of the water			significant difference in need for skin grafting (68.1% versus 49%). No statistical difference in hospital length of stay. Mortality rate was significantly higher in those receiving water first aid (42.9% versus 21.8%)		
Reidlinget al	Scald burns in children aged 14 and younger in Australia and New Zealand- An analysis based on the Burn Registry of Australia and New Zealand. Burns. 41:3;462-8. 2015	730 children were included in the study. Burns had to be severe enough to require hospitalization, surgical management, or death prior to discharge. They found a high rate of immediate cooling at the scene (89.1%) but only 20.5% received adequate first aid cooling (defined by minimum 20 minutes initiated within 3 hours of burn incident). Authors highlight need for better first aid education as only 1/5 of patients	Retrospective cohort	Low	Hospital length of stay was significantly shorter for those receiving adequate first aid cooling (2 days versus 2.9 days). No statistical significance in rates of surgical management between inadequate and adequate first aid cooling. This study was limited due to selection bias of patients that required specialized burn center care	Supports	2b

		received adequate burn cooling despite almost 90% receiving some form of cooling. Epidemiologic data from this study recommends targeting prevention programs to children aged 0-2 years (median age of cohort was 2 years old with 70% between 0-2 years old)					
Wood et al	Water First Aid is Beneficial in Humans Post-Burn: Evidence from a Bi-National Cohort Study. PLoS One. 11:1; e0147259. 2016	This study analyzed ages greater than 16 years old from the BRANZ registry, totaling 2320 patients. Median age was 36 years old and 75% male with majority of injuries at home (64%). See table 3 and figure 1 to analyze dose-response relationship. The study concluded that water cooling for 20-25 minutes in the first three hours after acute burn injury should occur to decrease rates of post-burn complications. They did not find significant benefit beyond 20 minutes and possibly harm at prolonged	Retrospective cohort	Low	Burn cooling was provided to 68% pre-admission with 46% hitting minimum 20-minute cooling. Study found a 13% reduction in grafting, 48% reduction in ICU admission, and 18% reduction in hospital length of stay when first aid provided. It showed a dose-response relationship with the duration time of cooling. Water first aid did not have significant associated reduction in risk of death	Supports	2b

		durations (<40 minutes)					
Harish et al	First aid improved clinical outcomes in burn injuries: Evidence from a cohort study of 4918 patients. Burns. 45:2;433-9. 2019	Of the 4918 patients, 58.1% received adequate first aid (minimum 20 minutes cool water within 3 hours of injury). Adequate first aid showed improved outcomes. These included reduced wound depth, faster healing.	Prospective observational cohort	Low	Statistically significant reduction in burn depth but not with reduction in TBSA or need for grafting. There was a 10% reduction in recovery time (1.9 less days). There was a 15% reduction in TBSA requiring grafting when adequate first aid applied	Supports	2a

Level of Evidence	**Definitions (See manuscript for full details)**
Level 1a	**Experimental and Population based studies** - population based, randomized prospective studies or meta-analyses of multiple higher evidence studies with substantial effects
Level 1b	**Smaller Experimental and Epidemiological studies** - Large non-population based epidemiological studies or randomized prospective studies with smaller or less significant effects
Level 2a	**Prospective Observational Analytical** - Controlled, non-randomized, cohort studies
Level 2b	**Retrospective/Historical Observational Analytical** - non-randomized, cohort or case-control studies
Level 3a	**Large Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 3b	**Small Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 4	**Animal studies or mechanical model studies**
Level 5	**Peer-reviewed Articles** - state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 6	**Non-peer reviewed published opinions -** such as textbook statements, official organizational publications, guidelines and policy statements which are not peer reviewed and consensus statements
Level 7	**Rational conjecture** (common sense); common practices accepted before evidence-based guidelines
Level 1-6E	**Extrapolations** from existing data collected for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.

References

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3. Cho YS, Choi YH: Comparison of three cooling methods for burn patients: A randomized clinical trial. Burns. 2017 May; 43(3):502-8.
4. Abraham JP et al. Estimating the time and temperature relationship for causation of deep-partial thickness skin burns. Burns. 2015 Dec;41(8):1714-1747
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6. Fadeyibi IO et al: Practice of first aid in burn related injuries in a developing country. Burns.2015 Sep; 41(6):1322-32
7. Riedlinger DI et al. Scald burns in children aged 14 and younger in Australia and New Zealand- An analysis based on the Burn Registry of Australia and New Zealand. Burns. 2015 May;41(3):462-8.
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9. Harish V, Tiwari N, Fisher OM, Li Z, Maitz PKM: First aid improves clinical outcomes in burn injuries: Evidence from a cohort study of 4918 patients. Burns. 2019 Mar;45(2):433-439.