

Rural Rounds: Frostbite Care in Rural ED

A.Poole MD FRCSC

Whitehorse

January 21,2026| 0800-0900



THE UNIVERSITY OF BRITISH COLUMBIA

Continuing Professional Development

Faculty of Medicine



Frostbite Care in the ED

A.Poole Whitehorse Yukon
2026

UBC Rural Rounds

Land Acknowledgement

I acknowledge that I work in Whitehorse on the traditional territories of the Ta'an Kwäch'än Council and Kwanlin Dün First Nation.





Declarations

- No Conflicts
- No Industry Funding
- Grant Funding:
NOAMA
SkIN Canada
- Photos

LEARNING OBJECTIVES

Grading

Differentiate the grades of frostbite injuries

Prognosis

Demonstrate how grade is related to prognosis

Treatment

Review the pathophysiologic rationale for medical management of frostbite



NEW | Yukon Arctic Ultra runner suffers severe frostbite

Doctors are working to save Polish runner Michal Kielbasinski's fingers

CBC News Posted: Feb 11, 2015 8:33 AM CT | Last Updated: Feb 11, 2015 8:55 AM CT



Michal Kielbasinski planned to run 700 kilometres from Whitehorse to Dawson City in the Yukon Arctic Ultra race. He suffered severe frost bite in the extreme cold conditions and was medevaced off the trail one day into the race. (Facebook)

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NEW SEASON.

Grade ?

- Grade vs Degree
- Risk of amputation?



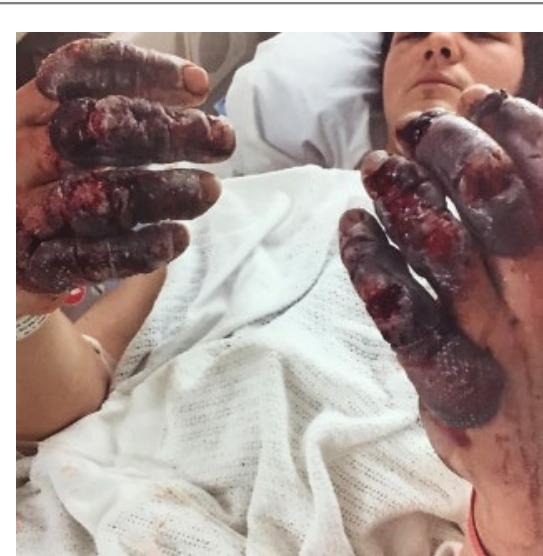
Natural History

- Cauchy Bone Scan Study
- Grade 3 Frostbite 83% Amputation Rate



Could we do better?





No Amputation!

Could we do this?

- Near 100% Risk of Amputation without aggressive management
- Can we avoid amputation?

Outline

- Epidemiology
- Pathophysiology
- Grading
- Prognosis
- Treatment
 - Prehospital
 - Hospital
- Research directions

Epidemiology

Epidemiology



Northern proportional injury ratio 7 in NWT/Nunavut *Int J Circumpolar Health* 2013;72



Urban Edmonton 10 yr review 53% EtOH, 16% Psych *J Trauma* 1990;30



Cold Finland
2.5/100000, -15°C *Int J Circumpolar Health* 2002;61

Severe (blisters) frostbite 1.1% annual incidence, 10.6% lifetime *Makinen et al Scand J Work Environ Health* 2009;35(5):384-393



Yukon: 2015-2020, 22 Grades 2 to 4, 12 grades 3&4, *CMAJ Open* 2021

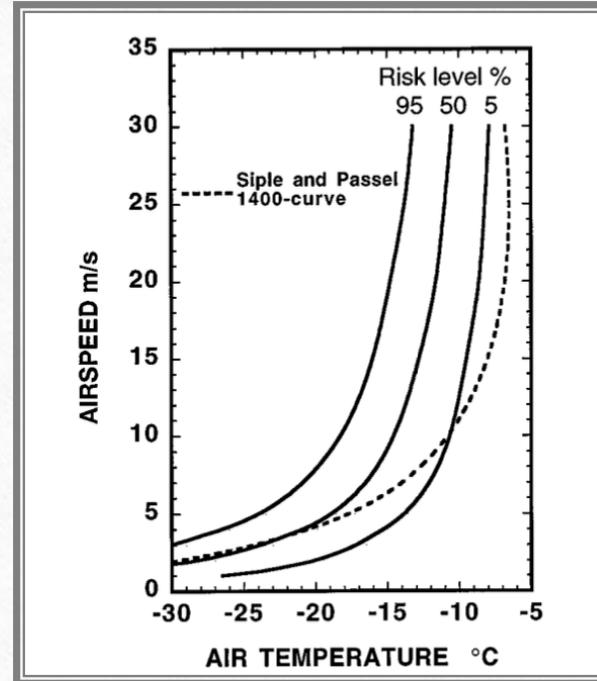


Prevention

Prevention ?

Windchill and Frostbite

- As the skin surface temperature falls from -4.8 to -7.8°C , the risk of frostbite increases from 5 to 95%.
- the risk of finger frostbite is minor above an air temperature of -10°C , irrespective of v
- below -25°C there is a pronounced risk, even at low v .



Extremity Cold Injury

Prefreeze

Freeze

Thaw

Danger Signs



Pain 15° Celcius



Numbness 7° Celcius



Frostbite 0° Celcius

Cheung Temperature 2:1, 105--120; January/February/March 2015



Freeze

Ok Now its frozen



Frostbite Signs and Symptoms

- Appearance
 - Palour, waxy, blue
 - Postthaw: pink, red, blue, grey
 - blisters, edema
 - eschar



Post Thaw



24 Hrs



48 Hrs

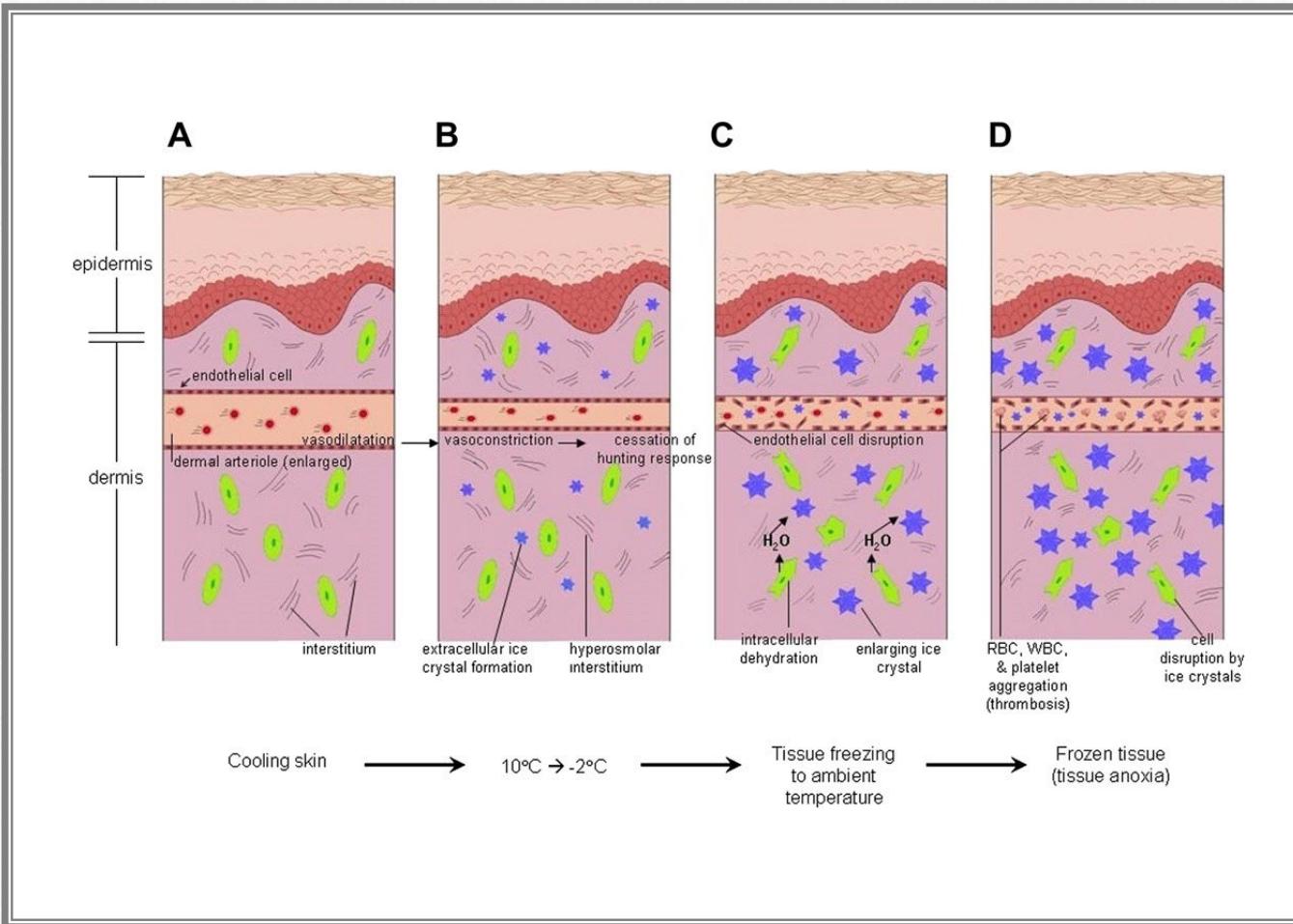
Difficult to tell full extent early

Pathophysiology

Freeze & Thaw

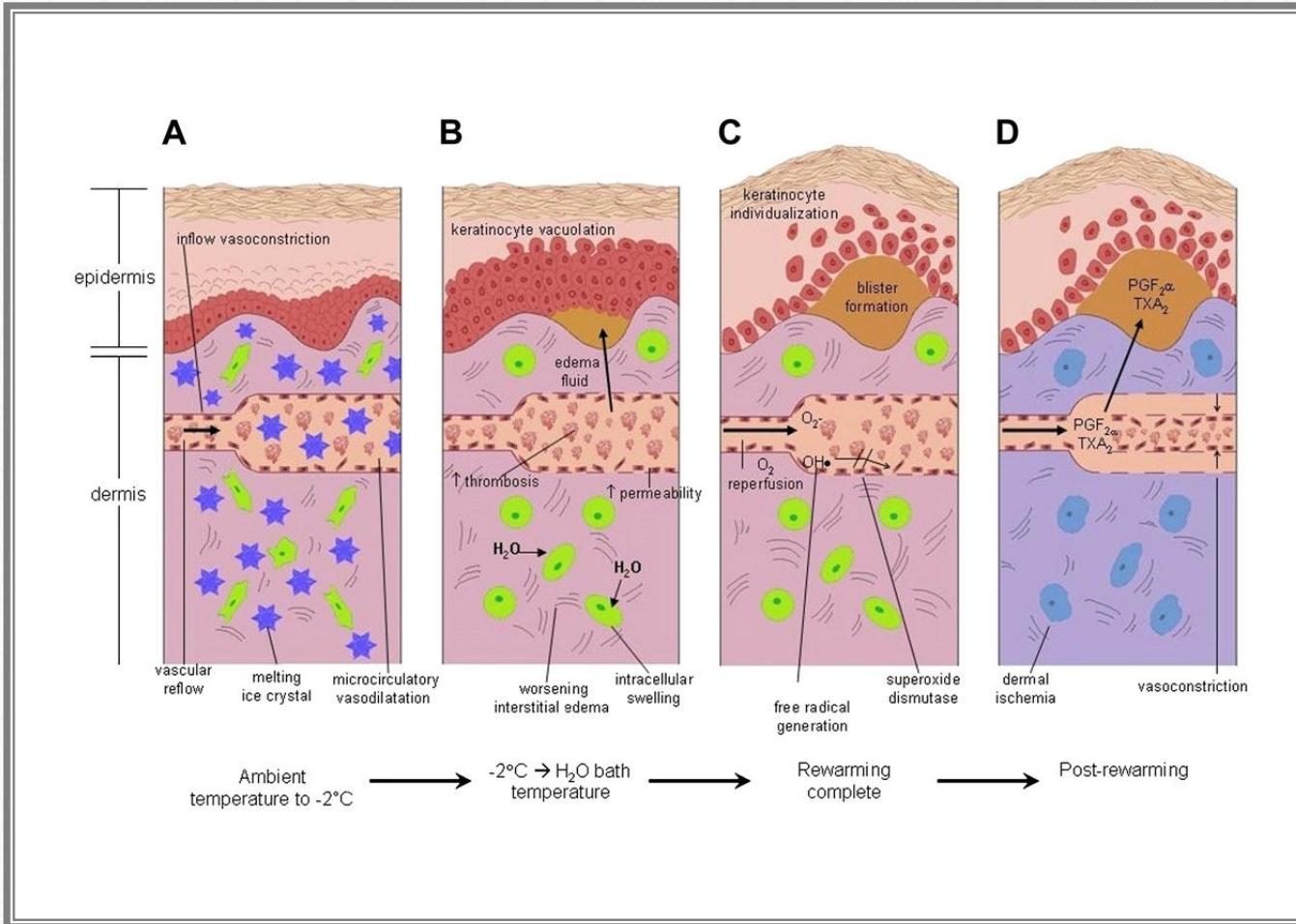
Freezing Injury

Extracellular Ice
Osmotic Changes



Thaw Injury

Vasoconstriction
Thrombosis



Warm Ischemia Time Matters

Time Matters in Severe Frostbite: Assessment of Limb/Digit Salvage on the Individual Patient Level

Rachel M. Nygaard, PhD, Alexandra M. Lacey, MD, Ashley Lemere, MD, Michelle Dole, DPM, Jon R. Gayken, MD, Anne L. Lambert Wagner, MD, Ryan M. Fey, MD

- Minnesota/Hennepin County
- 73 patients 2006 to 2014 bone scan perfusion defects
- 62% received thrombolysis
- Tpa 36% amputation, no tpa 50%
- **28% decrease in salvage rate with each hour passed after rewarming**
- *Journal of Burn Care & Research, 2017 jan 38 (1);53-59*
Nygaard et al

Absence
of cyanosis

Cyanosis
on
distal phalanx

Cyanosis
up to
MP joint

Cyanosis
proximal to
MP joint



Grading

Moving beyond classification and towards prognosis



Grade 1

No

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Grade 2

Grade 3

Grade 4

Risk of

Classification based on acute physical findings



- 1 degree
 - numbness, erythema, white, yellow plaque, mild edema
- 2 degree
 - clear blisters, edema, erythema
- 3 degree
 - deeper, hemorrhagic blisters
 - beneath dermal vascular plexus
- 4 degree
 - through dermis & into subcut tissue, into muscle +/- bone

Simplified Classification

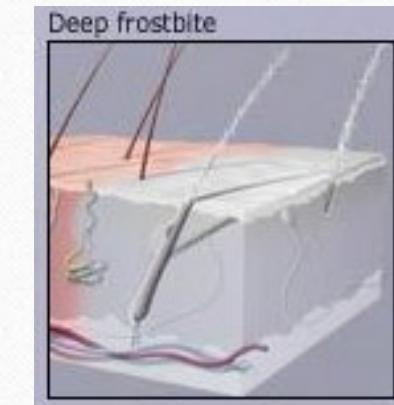
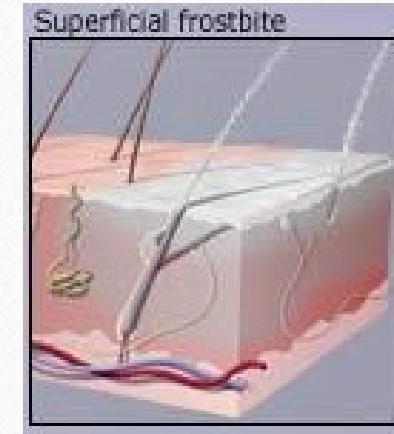
- 1 degree
- 2 degree
- 3 degree
- 4 degree

}

}

Superficial
minimal anticipated tissue loss

Deep
deeper injury & anticipated tissue
loss



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The role of bone scanning in severe frostbite of the extremities: a retrospective study of 88 cases

E. Cauchy¹, E. Chetaille¹, M. Lefevre², E. Kerelou¹, B. Marsigny¹

¹ Department of Mountain Medicine and Trauma, Chamonix Hospital, Chamonix, France

² Department of Nuclear Medicine, Bonneville Hospital, France

Received 16 September and in revised form 27 December 1999

Abstract. We performed a retrospective study of the re-

Eur J Nucl Med (2000) 27:497–502

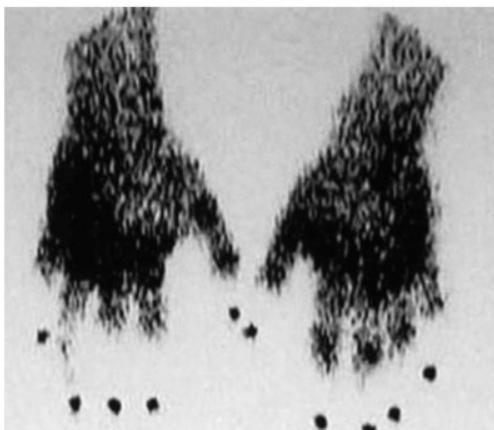


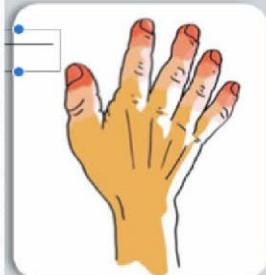
Fig. 4. Retrospective analysis of the bone scan in the patient in Fig. 3 shows that the areas without tracer uptake correlate well with the level of amputation



Fig. 3. Severe frostbite of the hand at day 45. The level of amputation has been determined by the surgeon in accordance with the bone vitality

Grades

- Grade 1: No Cyanosis, Amputation rate 0%
- Grade 2: Cyanosis of Distal Phalanx, No hemorrhagic blisters, Amputation rate 1%
- Grade 3: Cyanosis into Middle or Proximal Phalanx, Amputation rate 39-83%
- Grade 4: Metacarpal, Amputation rate 100%



1



2



3

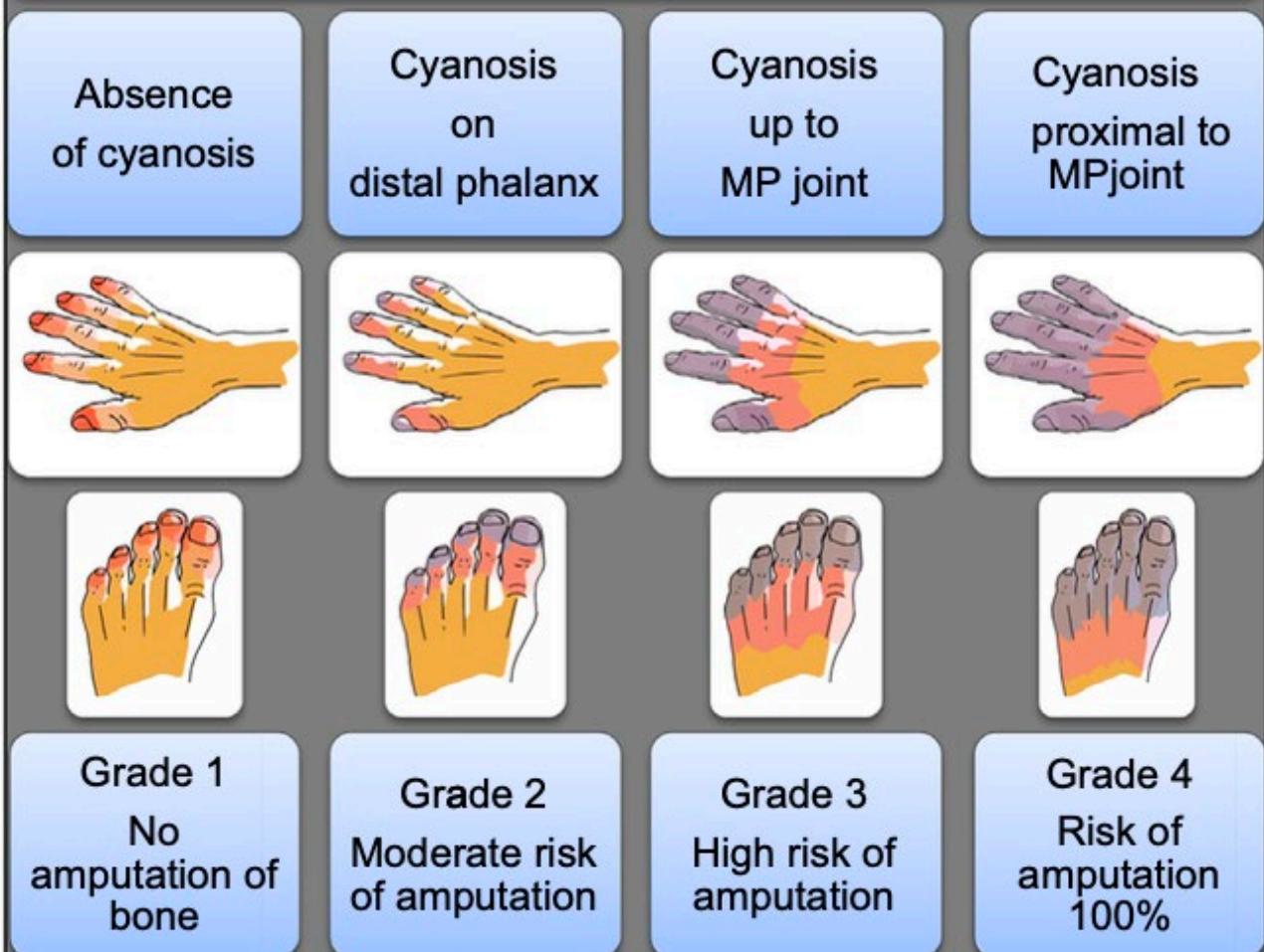


4

Grading severity of frostbite after rewarming

Simplified Grading

- Cyanosis and Hemorrhagic blisters
- As extends proximally amputation risk increases



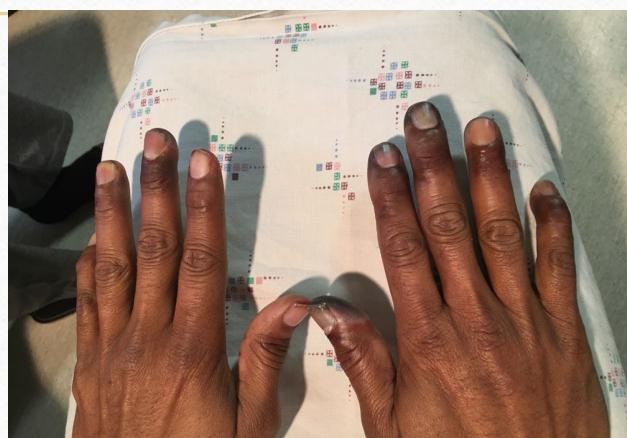
Grade 1: no cyanosis, no hemorrhagic blisters



Grade 2

- Cyanosis or hemorrhagic blisters of distal phalanx





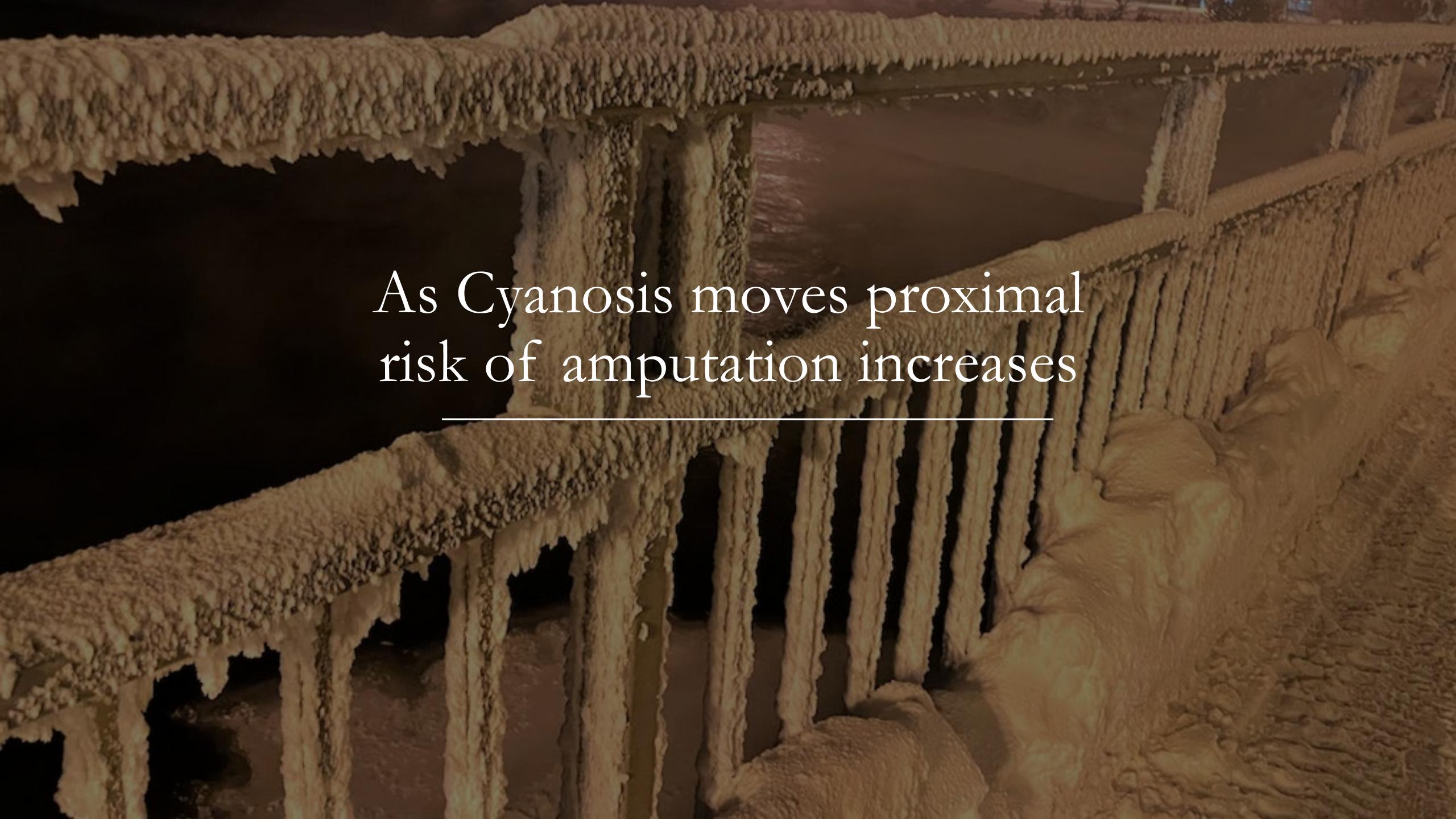
Grade 3

- Cyanosis or hemorrhagic blisters into mid/prox phalanx

Grade 4

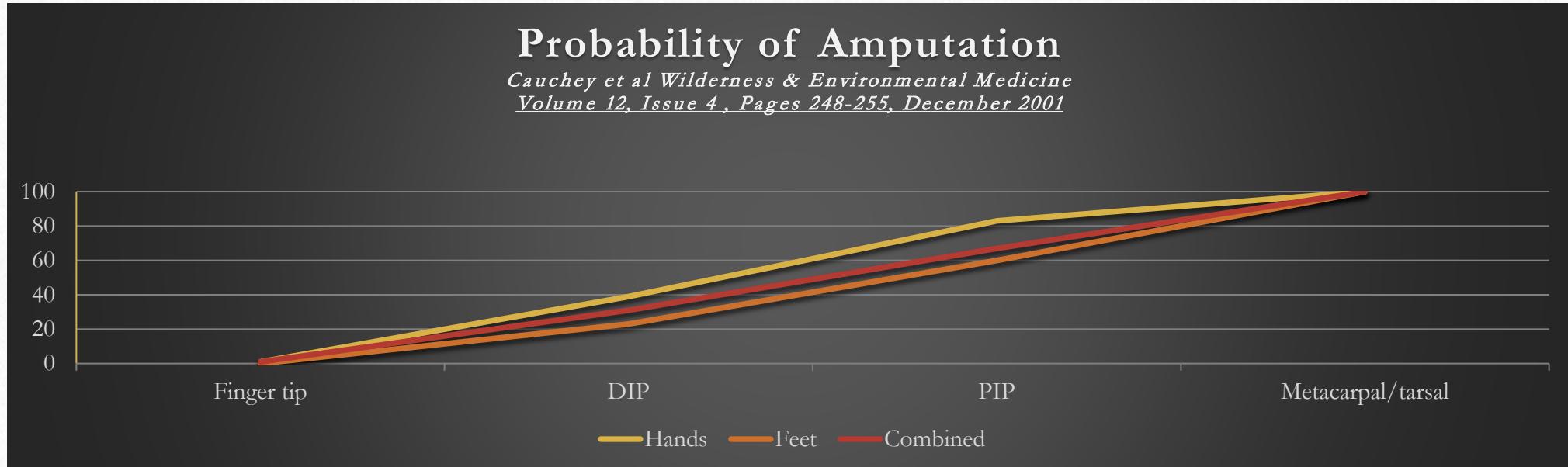
Cyanosis or hemorrhagic
blister into
Metacarpal/tarsal





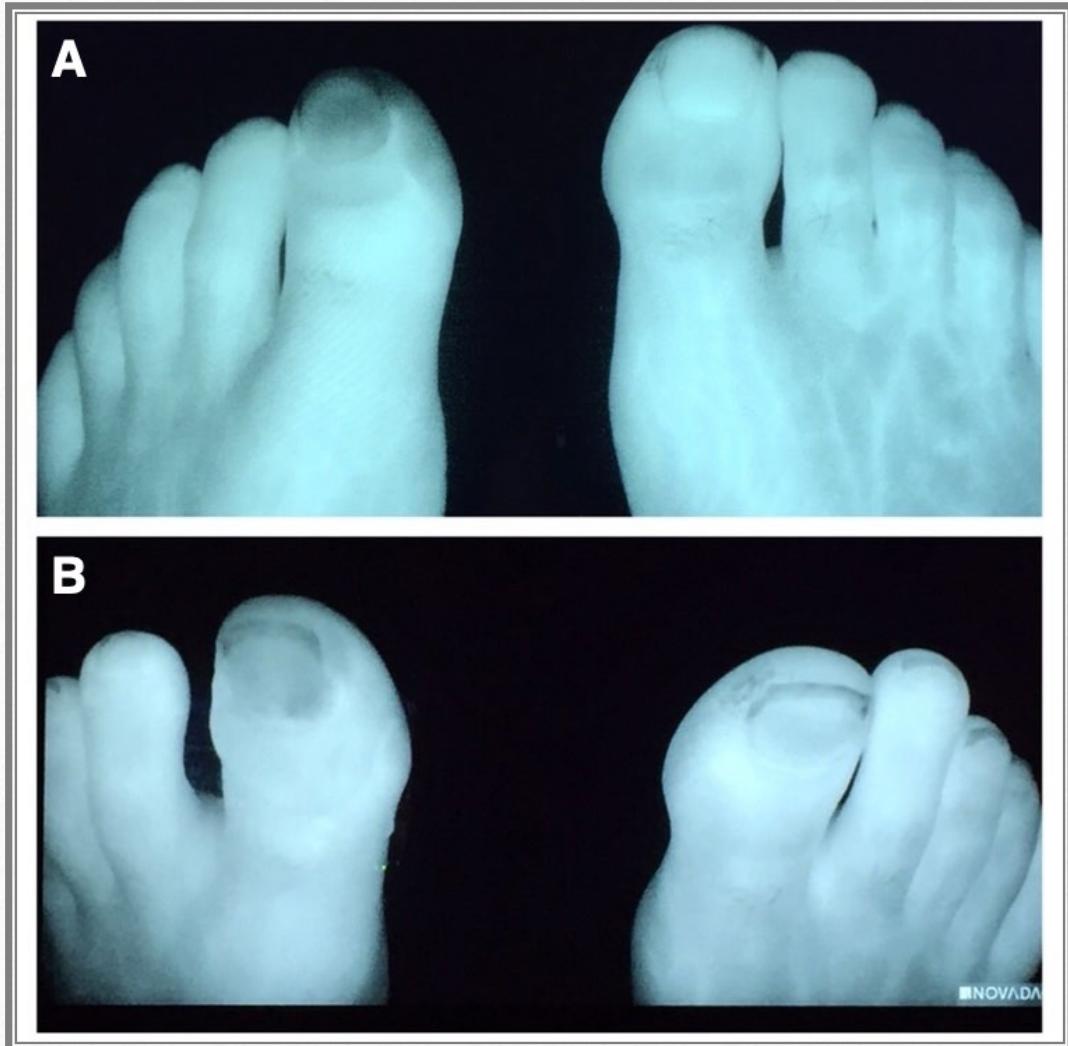
As Cyanosis moves proximal
risk of amputation increases

As cyanosis moves proximal risk of amputation increases



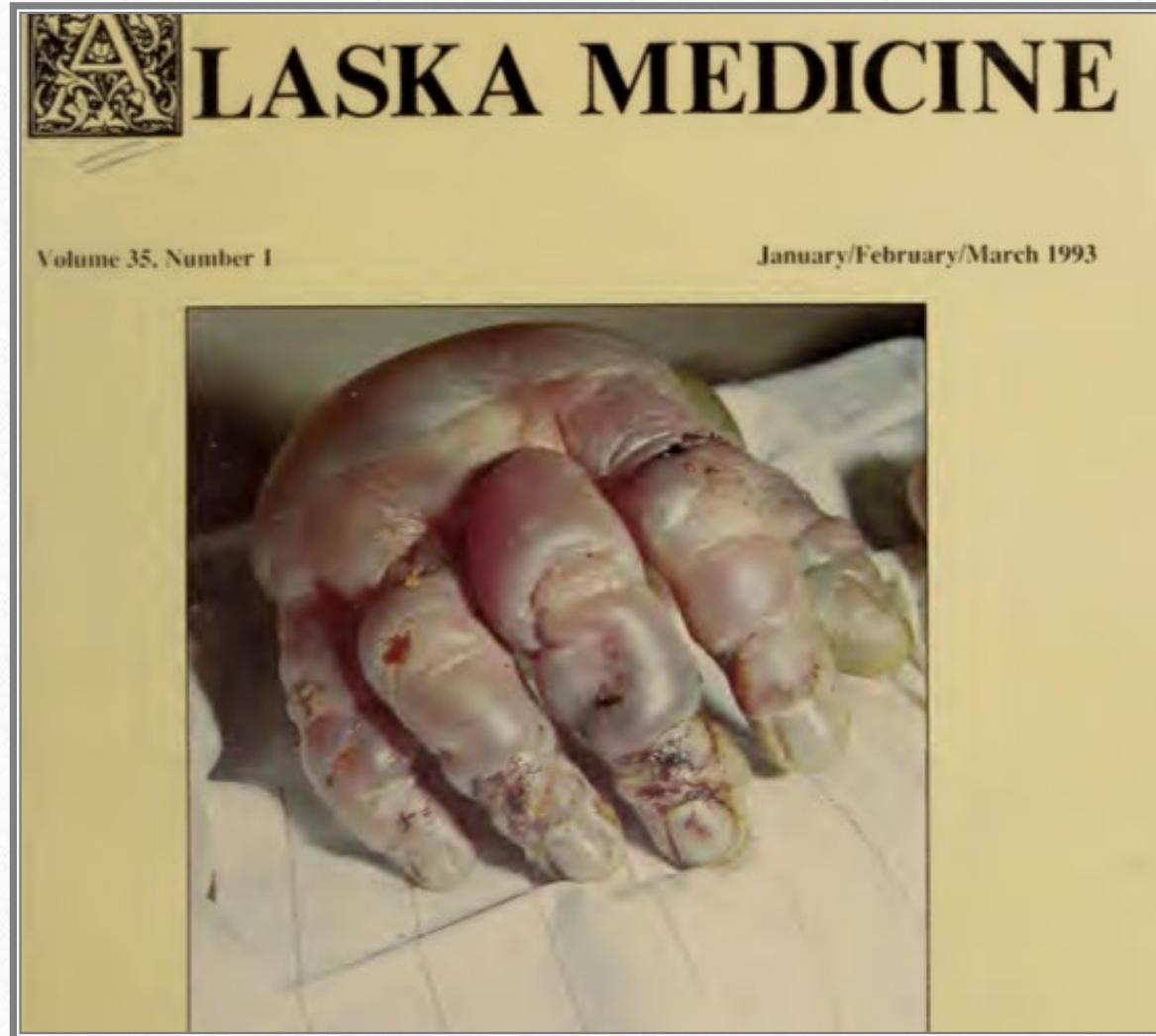
Imaging

- Plain Film: No
- Angiography: Yes
- U/S: perhaps doppler for flow
- CT angio: may not have necessary definition
- MRI: possibly
- Bone Scan: Yes
- Fluorescence: likely



Treatment

- Rapid Rewarming
- Early movement
 - Wound Care
 - Hydrotherapy
- Advanced Therapeutics
 - Avoid Surgery



REFREEZING IS A DISASTER!



Rewarming

Rapid rewarming is best

Spontaneous thawing is next best

Do not increase freezing time

Warm Water 37-39°C

Tolerable to unprotected hand for 30 sec

Until pink/purple and pliable



Treating in the field?

> *Wilderness Environ Med.* 2016 Mar;27(1):92-9. doi: 10.1016/j.wem.2015.11.014.

A New Proposal for Management of Severe Frostbite in the Austere Environment

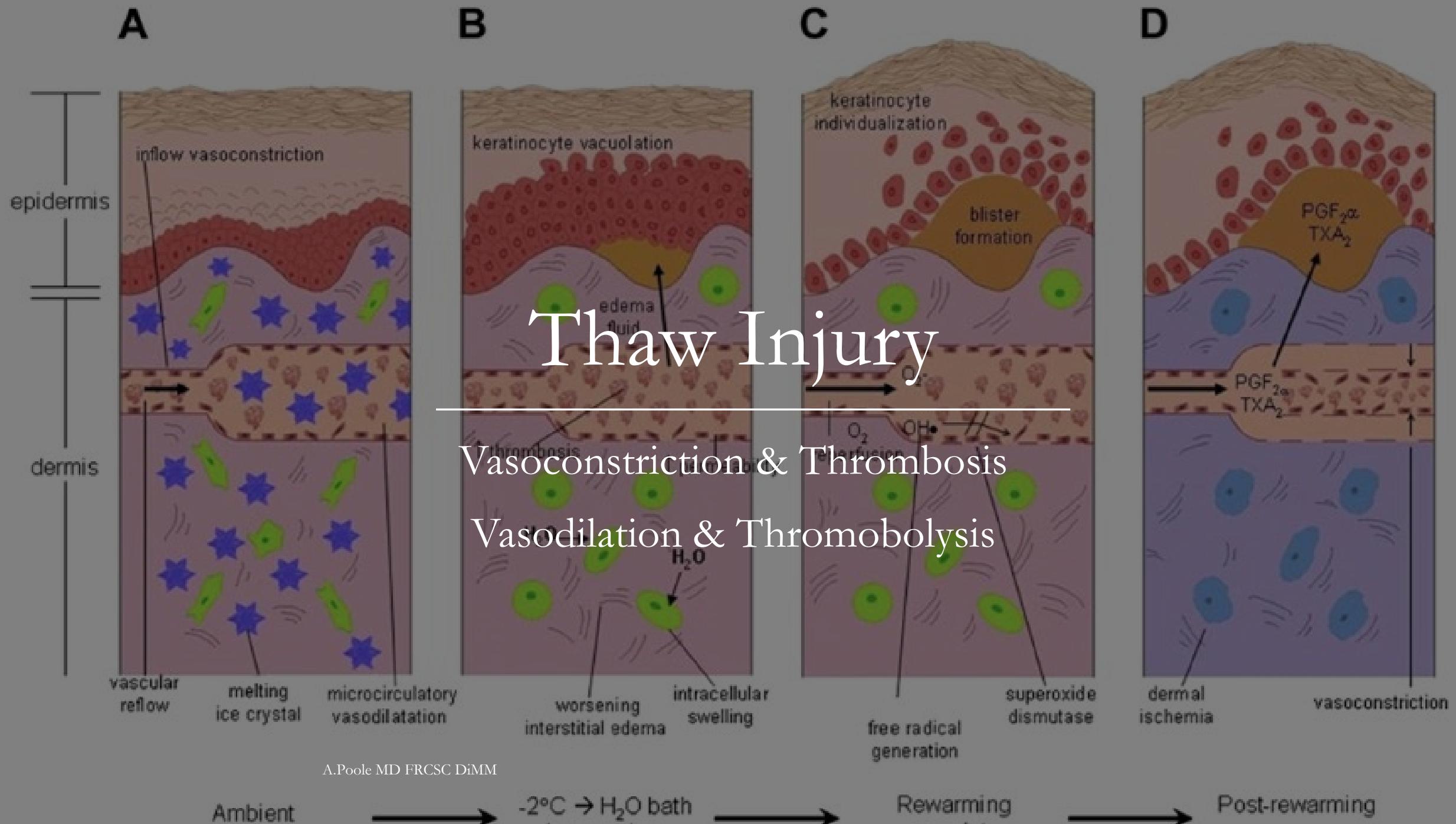
Emmanuel Cauchy ¹, Christopher B Davis ², Mathieu Pasquier ³, Eric F Meyer ⁴,
Peter H Hackett ⁵

- “We propose that thrombolytics and iloprost be considered for field treatment to maximize chances for recovery and reduce amputations”
- During Transport?

Case Report

Prehospital Frostbite Management With Iloprost: Case Reports of Two Helicopter Evacuations in Northern Canada

Pierre-Marc Dion, MD  ^{1,2}, Josianne Gauthier, MScPharm ³, Ryan Soucy, MEd, CCP ⁴,
Domhnall O'Dochartaigh, MSc, RN ⁵, and Alexander Poole, MD ⁶

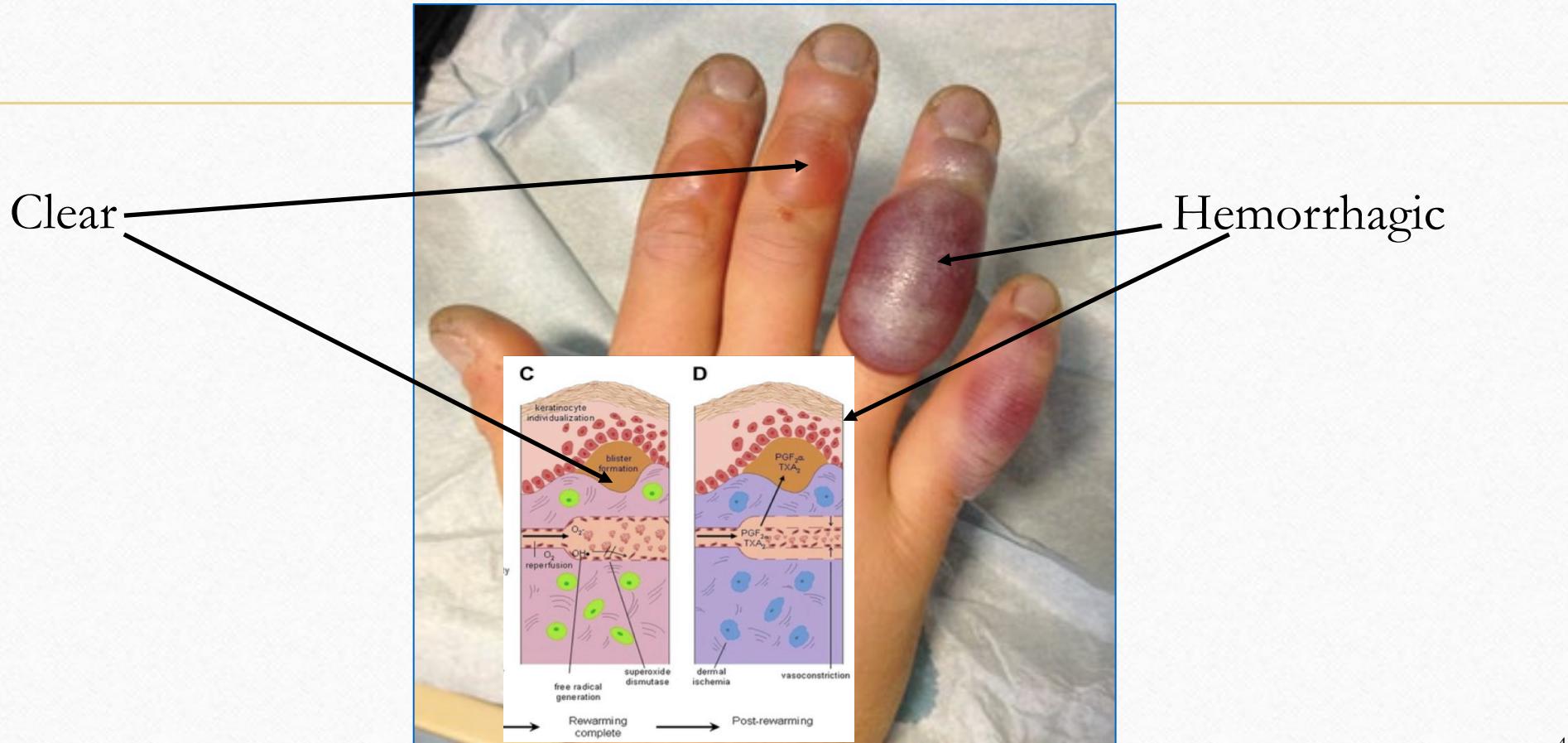




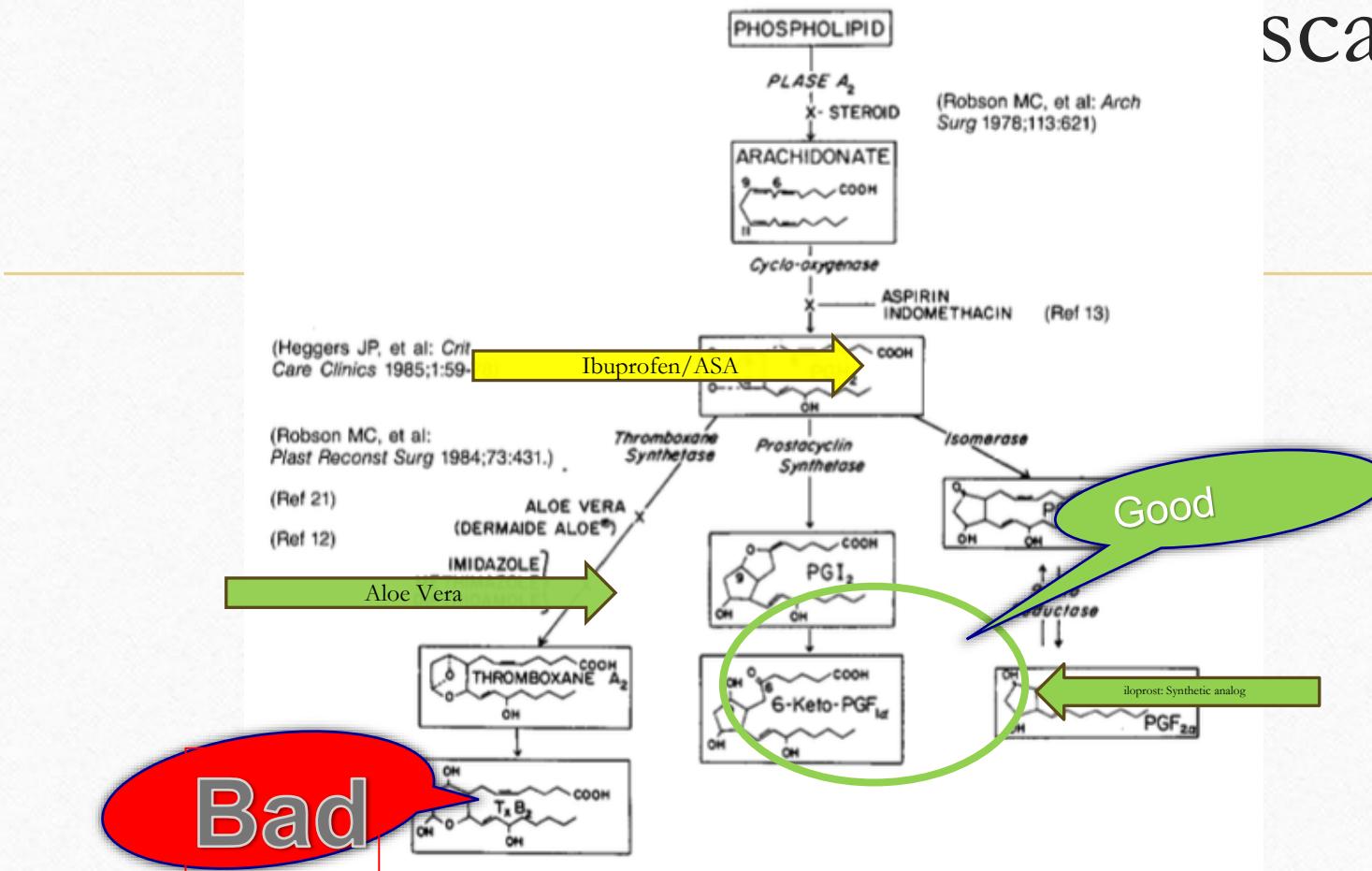
AntiThromboxane
Vasodilatation
Thrombolysis

Pharmacologic Treatment of Frostbite

What's the Deal with Blisters?



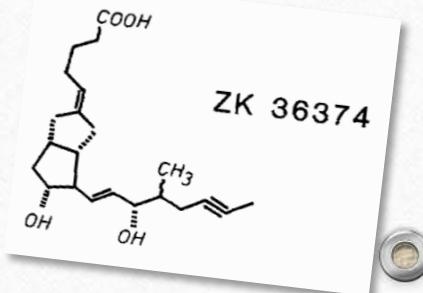
scade



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Hegers et al Ann Emerg Med 1987;16

**PGI₂= Iloprost
(synthetic analog)**



Thrombolysis

- Addressing post thaw microthrombi
- Multiple case reports, total in literature > 400, 25% amputation rate
- Twomey, Minnesota 19 patients *J Trauma 2005*
Gonzaga et al, Minnesota 62 patients over 14 yrs
J Burn Care Res 2015
- Bruen, Utah 6 patients 10% amputation vs 41% control
 - *Arch Surg 2007*
- 2 Cases at K2 base camp *Wilderness & Env Med 2016*

Thrombolysis Intravenous or Intra arterial?

Journal of Burn Care & Research
Volume 40, Number 5

Drinane et al 547

Table 3. Differences between patients treated with intravenous and intra-arterial thrombolytics

Treatment Route	No. of Patients (n)	Treatment Group (n)	Imaging Modality	Digits at Risk	Amputations	Overall Limb Salvage Rate (%)	Weighted Average Limb Salvage Rate (%)	Complication Rate, n (%)
Intravenous	166	110	Tc-99m triple-phase bone scan	923	134	85.5	77.3	6 (2.7)
Intra-arterial	159	106	Angiography ^a	921	212	77	76.4	8 (3.7)

^aA single study used bone scans to assess perfusion.

Time Matters in Severe Frostbite: Assessment of Limb/Digit Salvage on the Individual Patient Level

Rachel M. Nygaard, PhD, Alexandra M. Lacey, MD, Ashley Lemere, MD,
Michelle Dole, DPM, Jon R. Gayken, MD, Anne L. Lambert Wagner, MD,
Ryan M. Fey, MD

- **For each hour of delayed treatment, additional 27% loss of tissue (p=0.006)**

Vasodilation

Many tried

Only Iloprost has compelling evidence

Epoprostenol an alternative in NA

What does the Literature tell us?

INTERNATIONAL JOURNAL OF CIRCUMPOLAR HEALTH
2023, VOL. 82, 2189552
<https://doi.org/10.1080/22423982.2023.2189552>

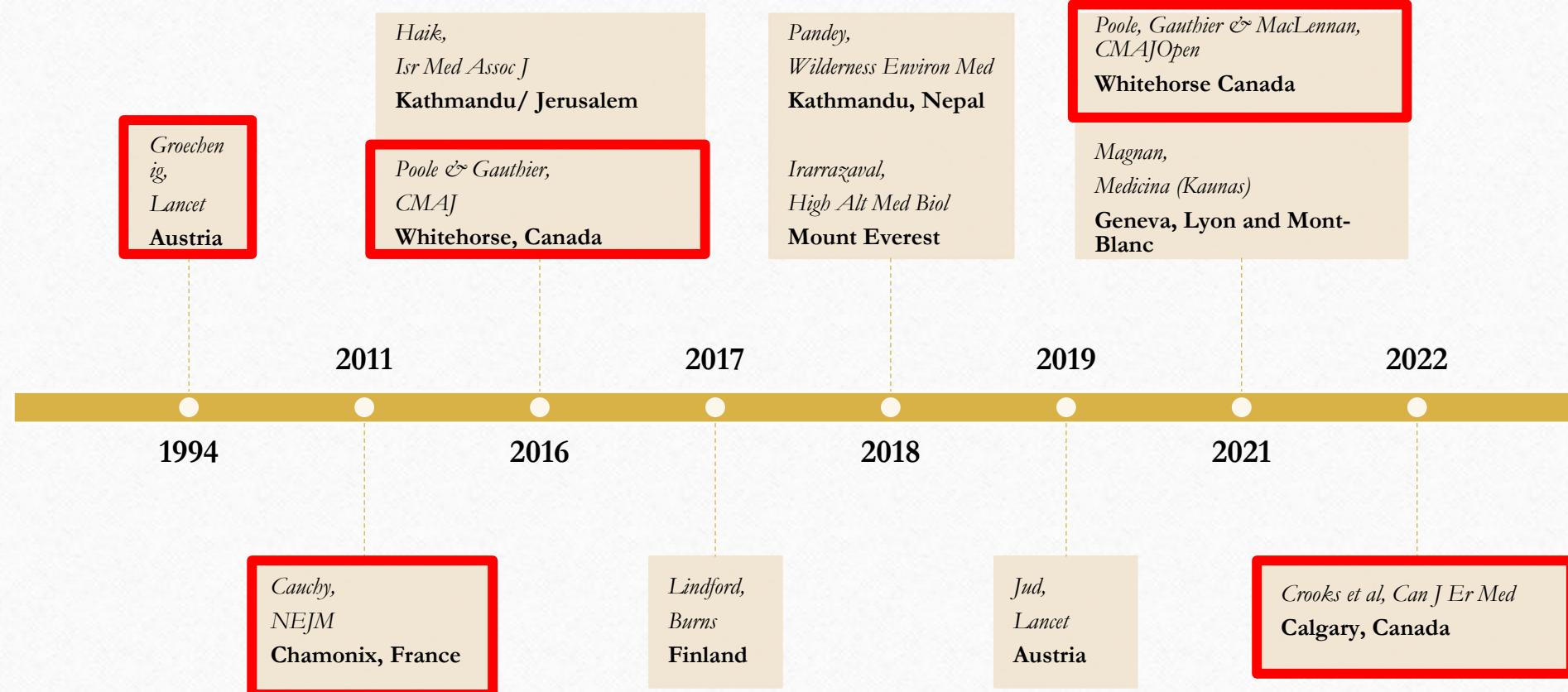
ARCTIC MILITARY CONFERENCE IN COLD WEATHER MEDICINE

Iloprost for the treatment of frostbite: a scoping review

Josianne Gauthier^a, Dunavan Morris-Janzen^b and Alexander Poole^{a,c}

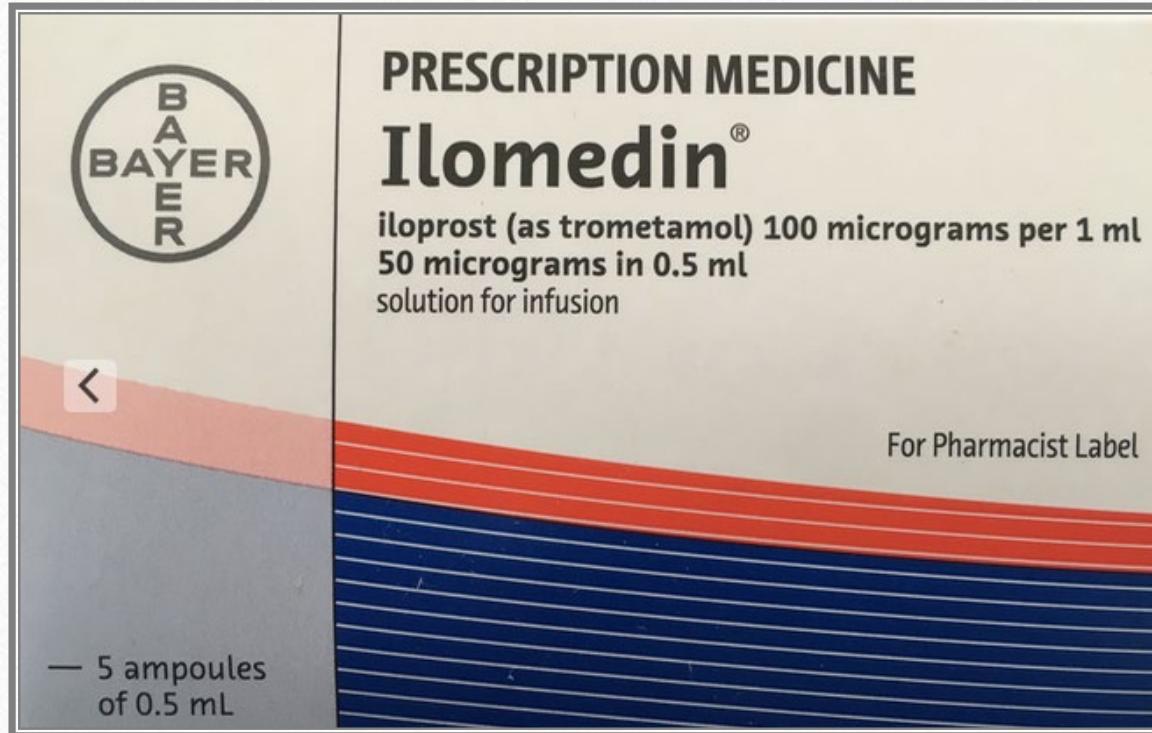
- 200 papers iloprost & Frostbite
- 1994-2022
- 20 papers in the literature
- All case series
- >200 patients
- >1000 digits

Iloprost



Why Iloprost?

- Stable analog of Prostacyclin
- Vasodilator, inhibits platelet aggregation, profibrinolytic and cytoprotective
 - Inhibits Thromboxane
 - decreases skeletal muscle ischemia-reperfusion injury
- Used in Raynauds and Thromboangiitis obliterans, Pulmonary hypertension



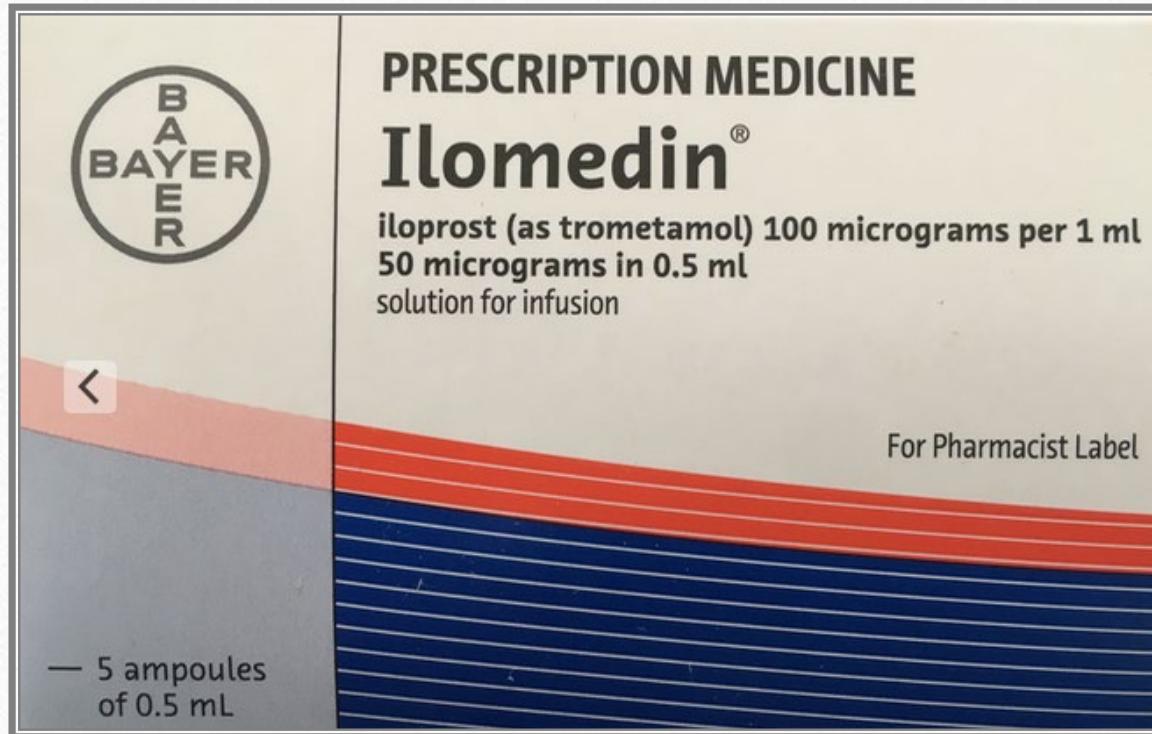
Why Not Iloprost?

Not Available in Canada or USA

CARIPUL® (epoprostenol) is similar
but only two reports of its use in
frostbite

Khan et al CHEST, Vol. 154, Issue 4, p826A–827A

Amir Eslami, Bradley Lauver CHEST, Vol. 156, Issue 4, A2109



Why Not Iloprost?

Not Available in Canada or USA

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Khan et al CHEST, Vol. 154, Issue 4, p826A–827A

Amir Eslami, Bradley Lauver CHEST, Vol. 156, Issue 4, A2109



PRESCRIPTION MEDICINE

FDA NEWS RELEASE

FDA Approves First Medication to Treat Severe Frostbite

[f Share](#) [X Post](#) [in Linkedin](#) [Email](#) [Print](#)

For Immediate Release: February 14, 2024

— 5 ampoules of 0.5 mL





Did Michael's Fingers Fall Off?

CASES

Treatment of severe frostbite with iloprost in northern Canada

Alexander Poole MD, Josianne Gauthier BPharm MScPharm



Figure 1: Case 1: A 46-year-old man with grade 3 frostbite on his right hand. (A) Day 1. (B) Day 2. (C) At one month. (D) At six months.

Poole & Gauthier CMAJ 2016 DOI:10.1503/cmaj151252

Aloe vera and Mepitel dressing
Elevation of affected parts
Avoid tobacco and alcohol
Tetanus-diphtheria
immunization

Management as per Grade 1
+
Iloprost intravenous infusion
for 6 hours for 5 days

Management as per Grade 1
+
Iloprost intravenous infusion
for 6 hours for 5 days

Grading severity of frostbite after rewarming Modern Protocol

Absence
of cyanosis



Cyanosis
on
distal phalanx



Grade
up to
MP joint

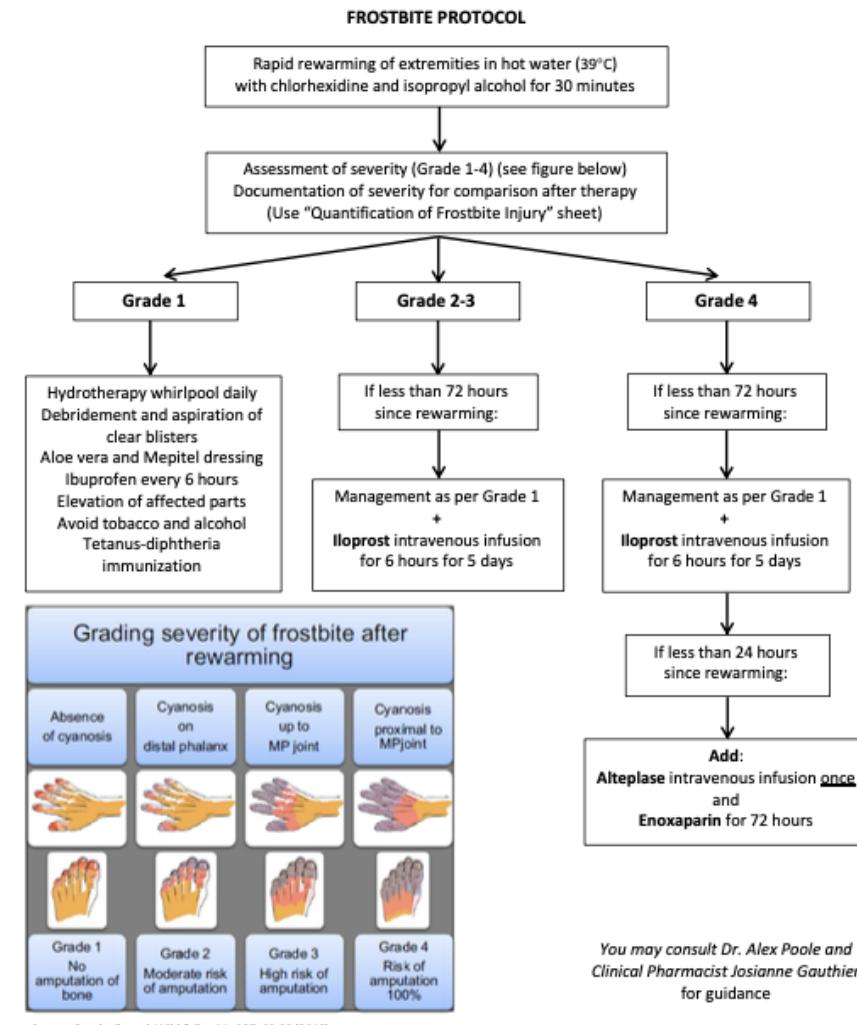


Rapid Rewarming/Ibuprofen/Iloprost/tPa
proximal to
MP joint

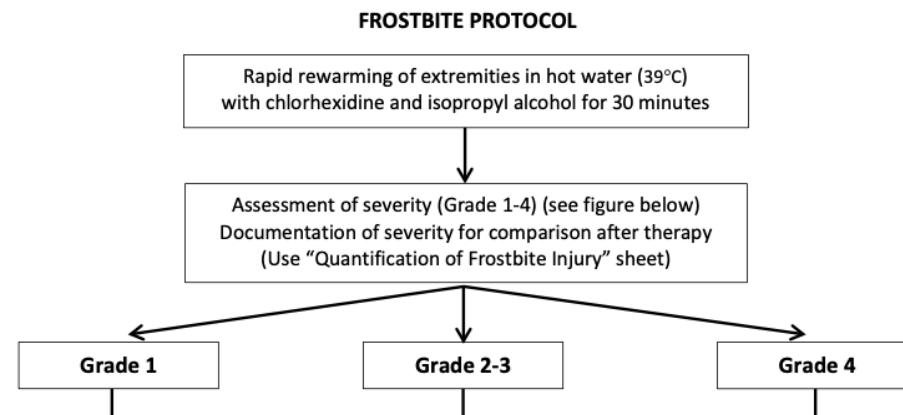
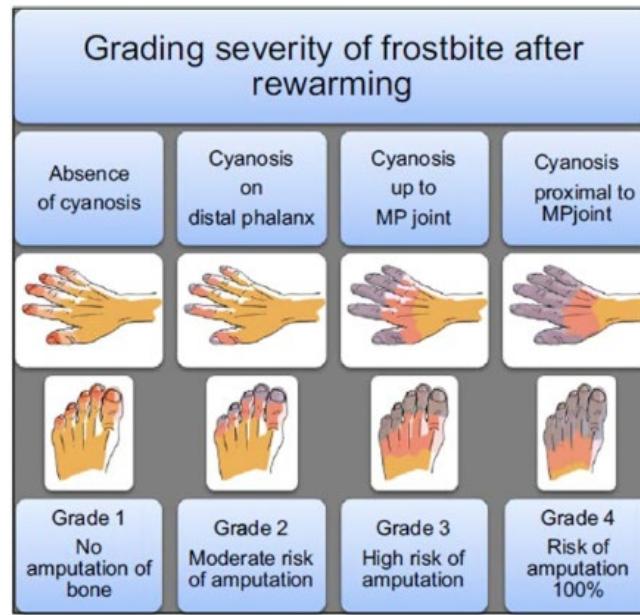


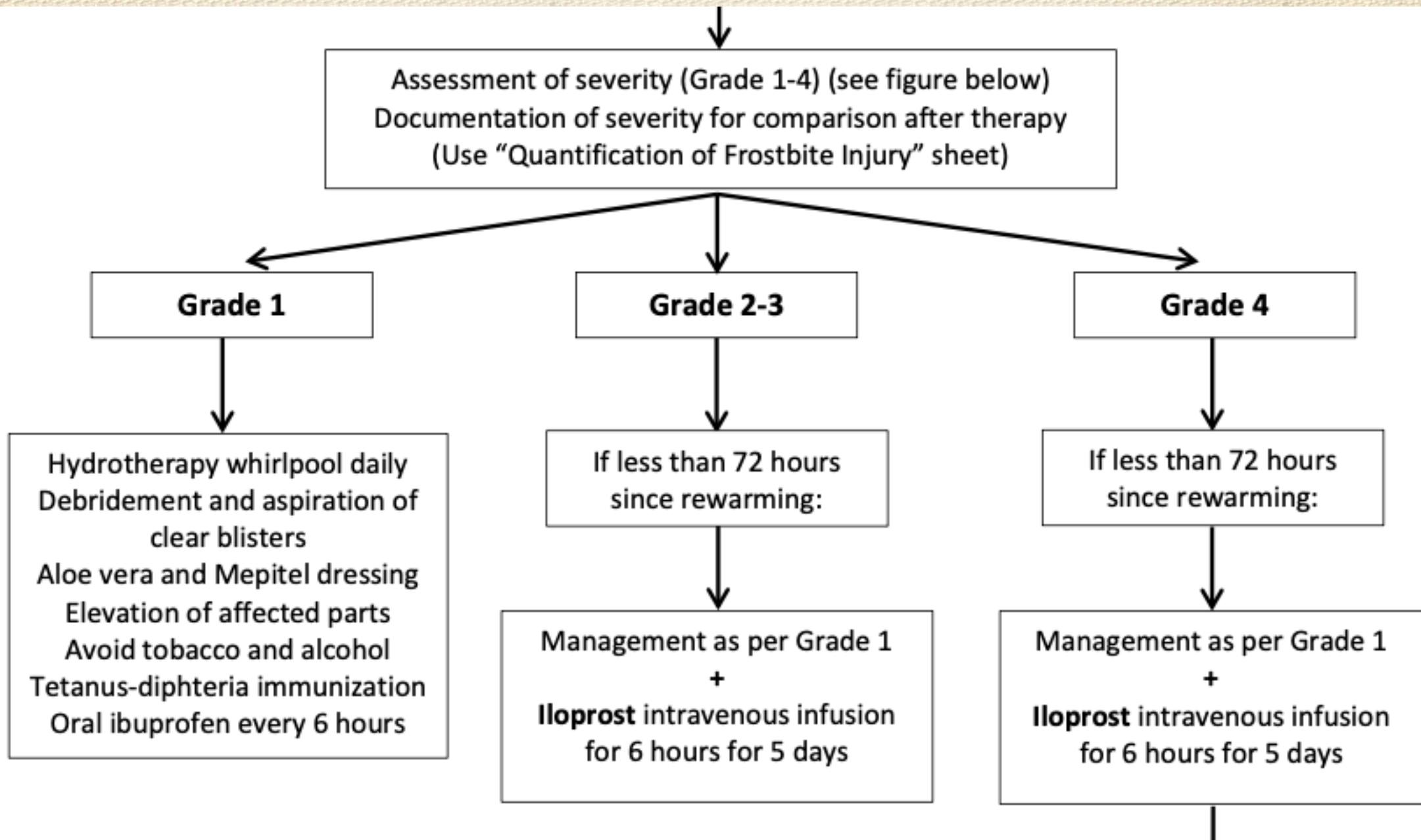
If less than 24 hours
since rewarming:

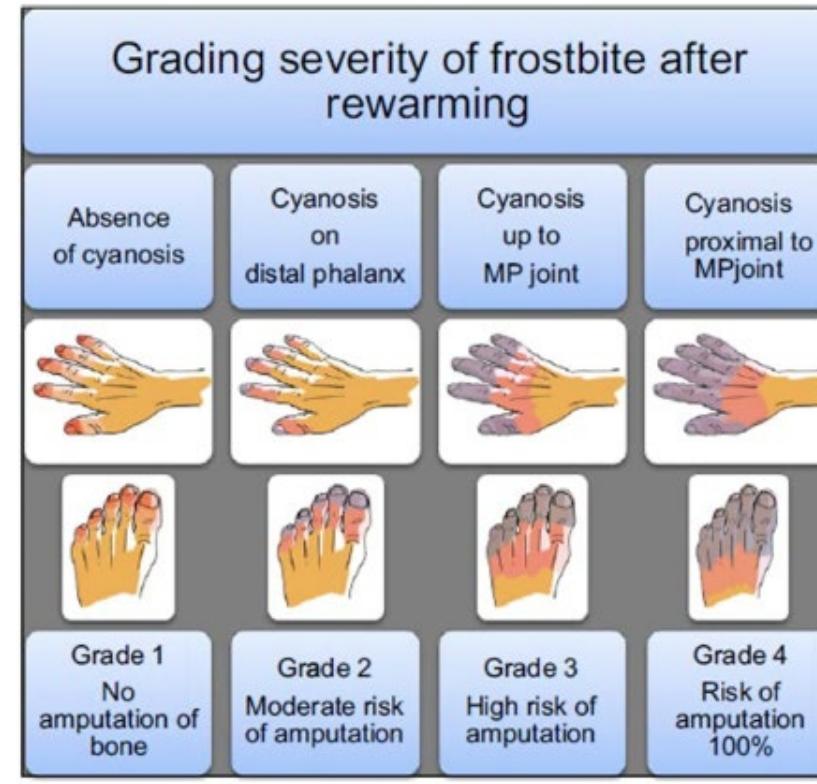
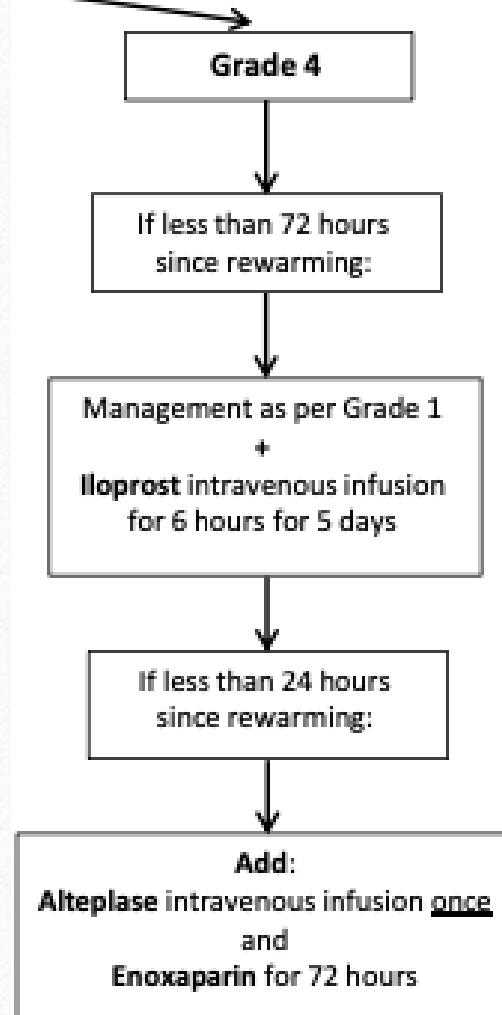
Add:
Alteplase intravenous infusion once
and
Frostbite Heparin Protocol
intravenous infusion
for 72 hours
(see page 3 of Pre-Printed Orders)



Triage







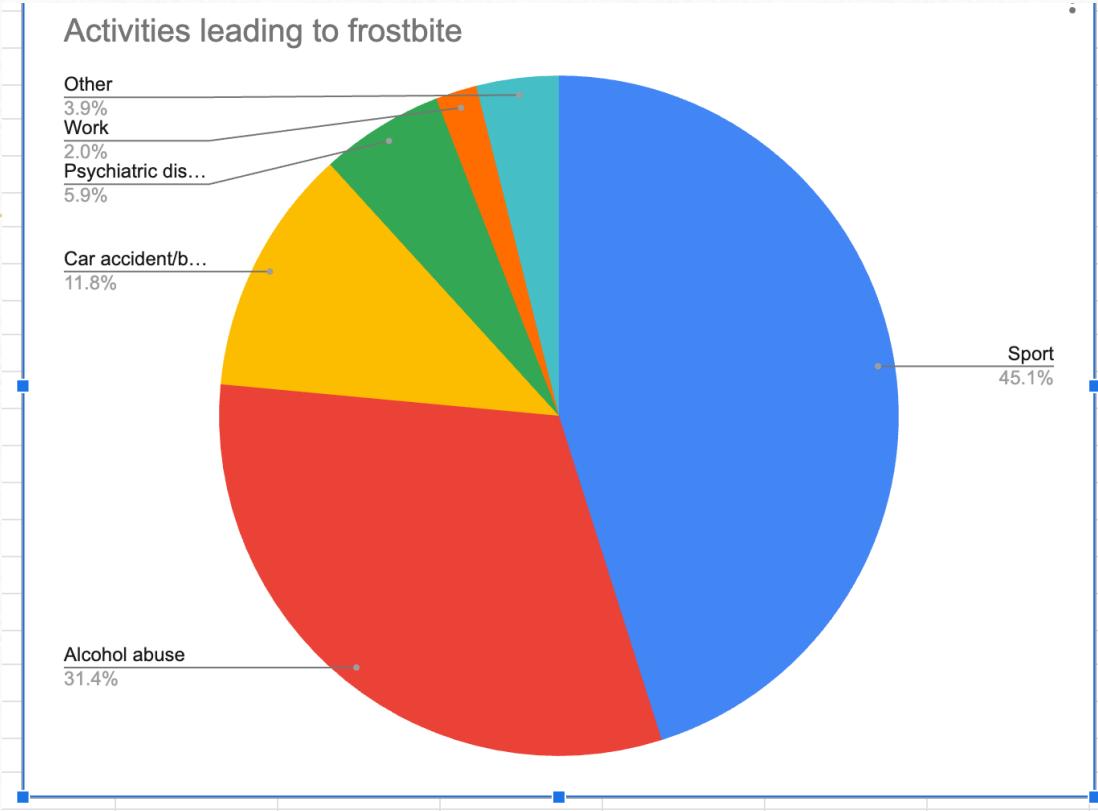
A black and white photograph of a majestic mountain range. The foreground shows a steep, snow-covered slope with a lone skier in a yellow jacket and black pants. The middle ground is filled with a dense forest of snow-laden evergreen trees. The background features several rugged mountain peaks under a clear blue sky.

10 Years of Protocol?

50 Cases Grade 2 to 4

Who gets frostbite?

- 45% Sports
- 31% Alcohol
- 12% Motor Vehicle Accident
- 6% Psychiatric



Poole, Gauthier, MacNairn unpublished

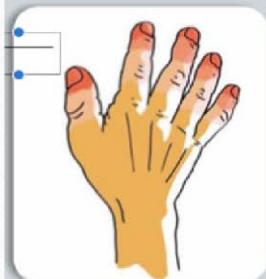
10 Yrs of Yukon Protocol

Grade	Patients	Digits @ Risk	Salvage Rate
2	19	87	100%
3	17	87	90%
4	12	113	62%

Poole, Gauthier, MacNairn unpublished

Grades

- Grade 1: No Cyanosis, Amputation rate 0%
- Grade 2: Cyanosis of Distal Phalanx, No hemorrhagic blisters, Amputation rate 1%
- Grade 3: Cyanosis into Middle or Proximal Phalanx, Amputation rate 39-83%
- Grade 4: Metacarpal, Amputation rate 100%



1



2



3



4

Grades/NHx

- Grade 2: Middle Phalanx, Amputation rate 1%
- Grade 3: Proximal/Middle Phalanx, Amputation rate 67%
- Grade 4: Metacarpal, Amputation rate 100%

Whitehorse(50)/Calgary(26)

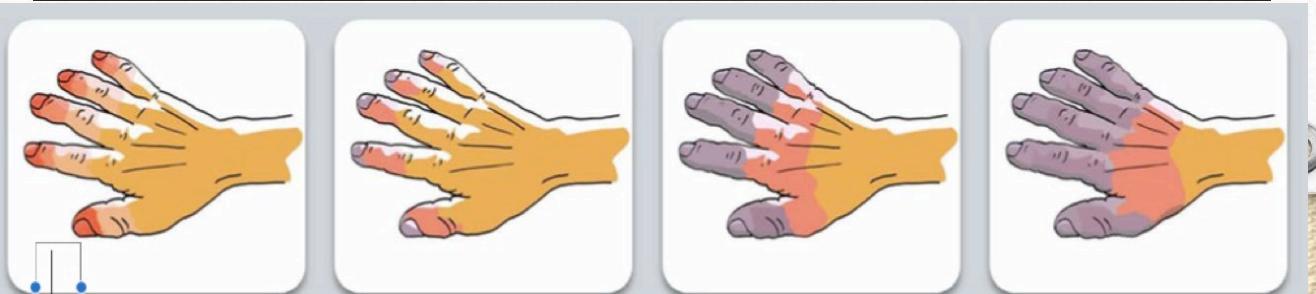
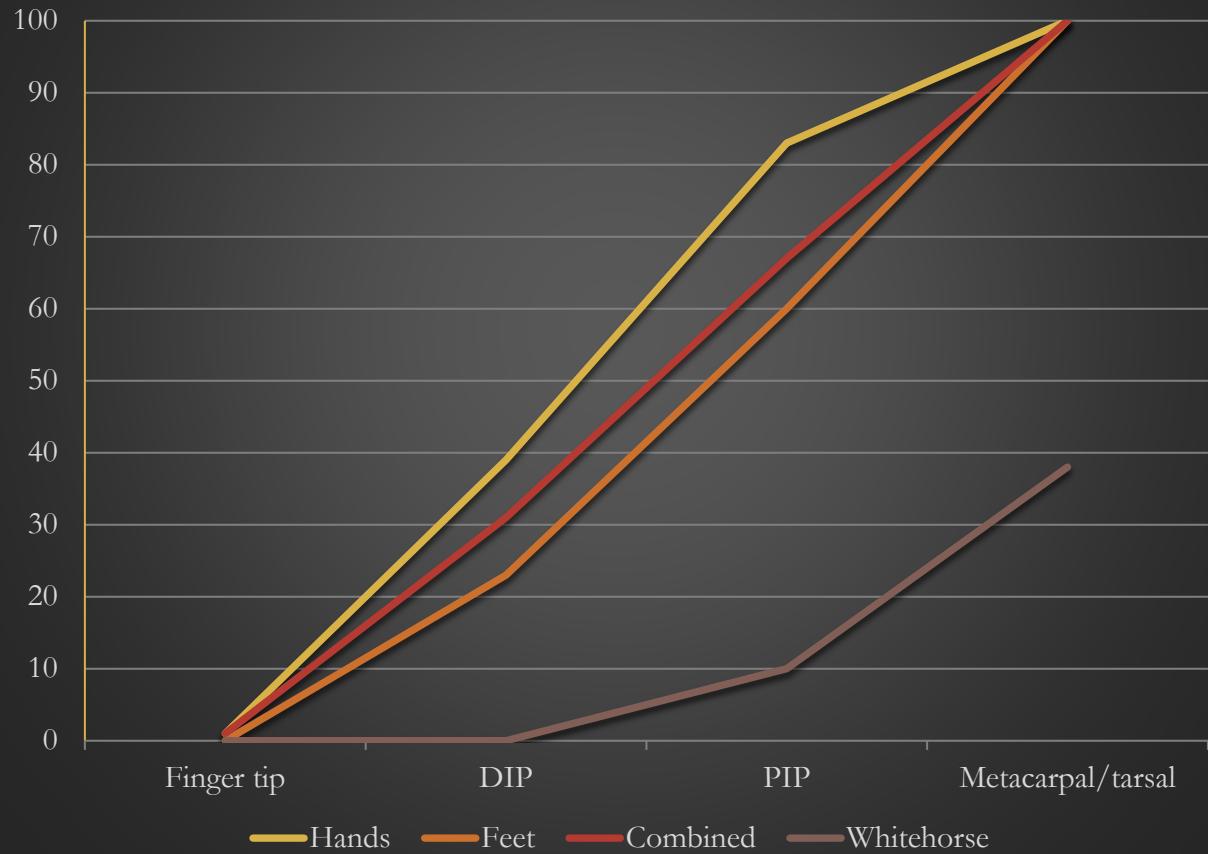
0%/0%

10%/18%

38%/46%

As cyanosis
moves
proximal
risk of
amputation
increases

Probability of Amputation
Cauchey et al Wilderness & Environmental Medicine
Volume 12, Issue 4, Pages 248-255, December 2001



Iloprost Side Effects

Number of patients with adverse drug reaction	62%
Headache	19 (38%)
Tachycardia > 100 bpm	16 (32%)
Nausea	12 (24%)
Flushing	10(20%)
Vomiting	3 (6%)
BP < 90/60	3 (6%)
Dizziness	3 (6%)
A.Poole MD FRCSC DiMM	
	<i>Poole, Gauthier, MacNairn unpublished</i>

Time from ER presentation to iloprost initiation (Hours)

Time From ER to iloprost Hrs

40

30

20

10

0

2016

2018

2020

2022

2024

Year

A.Poole MD FRCSC DiMM

Having a Protocol Makes a
Difference

Lessons Learnt Along the WAY

The earlier you treat the better, but the harder to grade

Treat grade 2 to avoid missing a grade 3

Simple monitoring ok, outpatient therapy works well

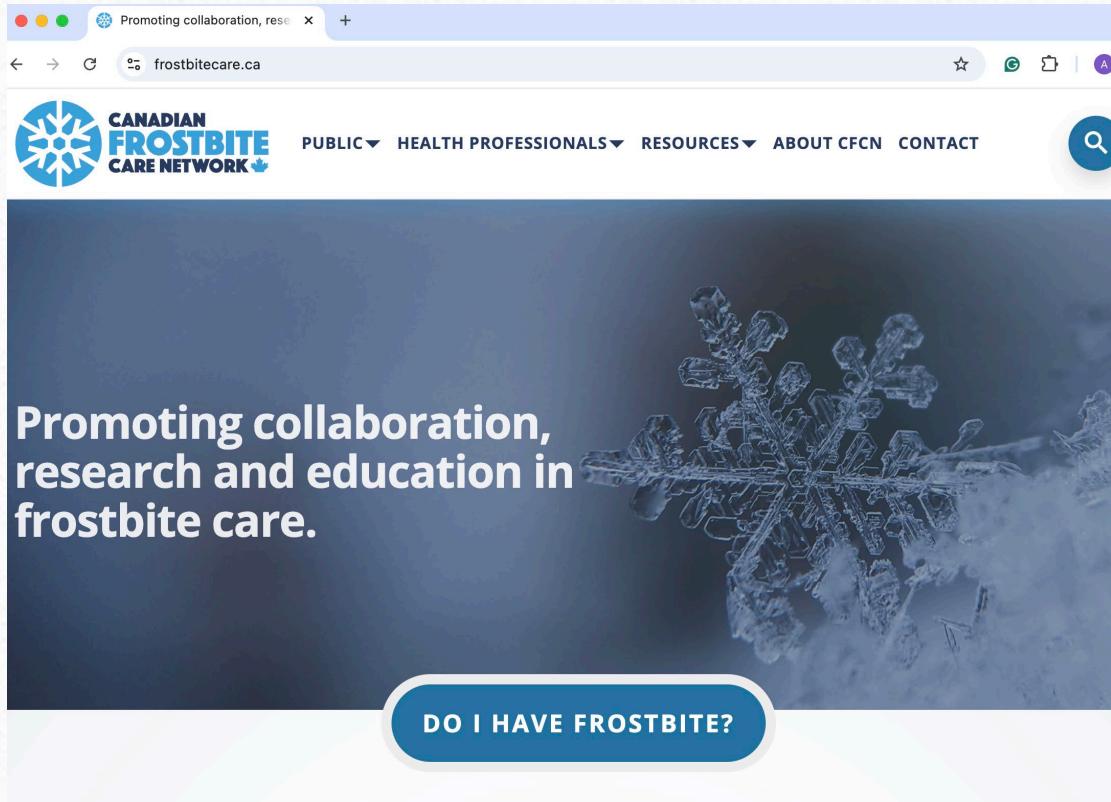
Dosing: 6 hrs vs full ampoule?

Prehospital protocol

A road sign for route 806 to Skjóadalur is mounted on a post in a snowy, rural landscape. The sign is yellow with black text. The route number '806' is on the left, and the destination 'Skjóadalur' is on the right. The background shows snow-covered fields and distant hills under a cloudy sky.

Where do we go from
here?

What do we need to learn?



What is next?

- Warm ischemia as it pertains to transport
- Frostbite Registry
- Do we need Thrombolysis?
- Iloprost vs tPa vs combination
- Dosing



CANADIAN
FROSTBITE
CARE NETWORK

Promoting collaboration,
research and education in
frostbite care.

DO I HAVE FROSTBITE

The Canadian Frostbite Care Network
group of Canadian health care



CANADIAN
FROSTBITE
CARE NETWORK

PUBLIC

HEALTH PROFESSIONALS

RESOURCES

ABOUT CFCN

CONTACT



Promoting collaboration,
research and education in
frostbite care.

DO I HAVE FROSTBITE

The Canadian Frostbite Care Network

<https://frostbitecare.ca/health-professionals/managing-frostbite>

PUBLIC

HEALTH PROFESSIONALS

FROSTBITE
PATHOPHYSIOLOGY

RECOGNIZING FROSTBITE

MANAGING
FROSTBITE

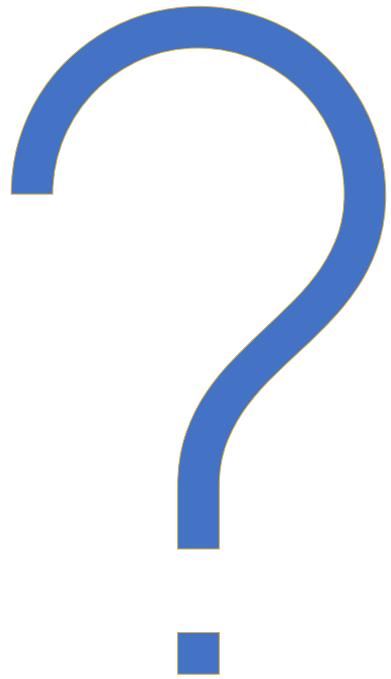
FROSTBITE CLINICAL
PRACTICE GUIDELINES
AND CARE PROTOCOLS

CONNECT WITH A
FROSTBITE CARE
PROVIDER

RESOURCES

ABOUT CFCN

CONTACT



Questions?

Longterm Sequelae

- 670 frostbite patients many suffered from long-term sequelae.
- neuropathy-related signs and symptoms (chronic dysesthesia, chronic pain, and hyperhidrosis),
- arthritis—even after lower-grade frostbite in healthy individuals.
 - Cold intolerance
- *Regli et al Long-Term Sequelae of Frostbite—A Scoping Review. Int J Environ Res Public Health. 2021 Sep 14;18(18):9655*

 International Journal of
Environmental Research
and Public Health



Review

Long-Term Sequelae of Frostbite—A Scoping Review

Ivo B. Regli ^{1,2,*}, Giacomo Strapazzon ^{1,3}, Marika Falla ^{1,4}, Rosmarie Oberhammer ⁵ and Hermann Brugger ^{1,3}