Chapter 4 – Non-Freezing Cold Injuries

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Cold Injuries can be of the "Freezing" (Frostbite) or Non-Freezing Variety (Non-Freezing Cold Injury, NFCI).

Human tissue freezes at around –0.55°C and depending on the rate of freezing intracellular crystals may form (rapid cooling) causing direct mechanical disruption of the tissues. The more common slow cooling and freezing results in predominantly extracellular water crystallisation that increases plasma and interstitial fluid osmotic pressure. The resulting osmotic outflow of intracellular fluid raises intracellular osmotic pressure and can cause damage to capillary walls. This, along with the local reduction in plasma volume, causes oedema, reduced local blood flow and encourages capillary sludging. These changes can produce thrombosis and a gangrenous extremity. The risk of frostbite is low above air temperatures of –7°C, irrespective of wind speed, and becomes pronounced when ambient temperature is below –25°C, even at low wind speeds.

NFCI is the term given to describe a condition that results from protracted exposure to low ambient thermal conditions, but in which freezing of tissues does not occur. Immobility, posture, dehydration, low fitness, inadequate nutrition, constricting footwear, fatigue, stress or anxiety, concurrent illness or injury can all increase the likelihood of NFCI.

The precise pathophysiology NFCI is poorly understood; the injury appears to be to the neuro-endothelio-muscular components of the walls of local blood vessels. Opinions vary as to whether the primary damage is vascular or neural in origin; or, whether the aetiology is primarily thermal, ischaemic, post-ischaemic reperfusion, or hypoxic in origin. The chronic sequelae of mild to moderate cold injury are: "cold sensitivity" (protracted cold vasoconstriction following a cold stimulus) and hyperhidrosis (local increased sweating), both of which accentuate local cooling and thus increase future risk of cold injury.

Frostbite

Non-Freezing Cold Injury

Figure 4-1 (Pictures courtesy of the Cold Injuries Clinic, Institute of Naval Medicine, UK).

TREATMENT

It is important to establish whether the dominant injury is freezing (FCI) or non-freezing (NFCI) in nature; this determines the preferred method of re-warming. In all cases shelter should be sought. Because casualties with cold injury are likely to be hypothermic they should be kept warm.

Frostbite

All cases of freezing injury should be thoroughly re-warmed by immersion of all the chilled part in stirred water at 38 – 42°C. A topical anti-bacterial should also be diluted into the water bath. Re-warming should be delayed if there is a chance that refreezing may occur.

Thawing a FCI can be intensely painful. Conventional and narcotic analgesics should be provided as necessary. Continuing treatment for FCI is a twice daily, 30-minute immersion of the affected part in a 38 – 42°C whirlpool bath containing an appropriate anti-bacterial.

NFCI

In contrast to those with FCI, patients with NFCI should have their affected extremities re-warmed slowly, by exposure to warm air alone, and must not be immersed in warm water. The early period after re-warming can be very painful in NFCI, even in those without any obvious tissue damage. Amitriptyline (10 – 75 mg in a single dose at night) is the drug of choice for the treatment of pain following NFCI, and should be given as soon as pain is felt. Amitriptyline may cause drowsiness and hypertension.

With either form of injury, once re-warmed, the affected extremities should be treated by exposure to air and early mobilisation. Smoking should be prohibited.

ASSESSING THE RISK OF COLD INJURIES

The cooling power of the environment is the result of air temperature and air movement or movement through air (e.g. as when skiing). These factors are combined into the Wind Chill Index, which illustrates the cooling effect of temperature and wind on bare skin and predicts the associated danger of cold injury.

Table 4-1: Wind Chill Chart – Effect of Increasing Wind Speed on Degree of Cooling at Different Ambient Temperatures

Ambient Temperature (°C)										
	4	-1	-7	-12	-18	-23	-29	-34	-40	-46
Wind Speed (mph)	Wind Chill (Equivalent) Temperature (°C)									
5	2	-4	-12	-15	-21	-26	-32	-37	-43	-48
10	-1	-9	-15	-23	-29	-37	-34	-51	-57	-62
15	-4	-12	-21	-29	-34	-43	-51	-57	-65	-73
20	-7	-15	-23	-32	-37	-46	-54	-62	-71	-79
25	-9	-18	-26	-34	-43	-51	-59	-68	-76	-84
30	-12	-18	-29	-34	-46	-54	-62	-71	-79	-87
35	-12	-21	-29	-37	-46	-54	-62	-73	-82	-90
40	-12	-21	-29	-37	-48	-57	-65	-73	-82	-90
	Less Danger			Increasing Danger. Flesh may freeze within a minute			Great Danger. Flesh may freeze within 30 seconds			

Equivalent temperature is the environmental temperature that would have the same effect on bare skin in the absence of any wind (equivalent cooling power).

REFERENCES

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