Clinician's Commentary on Bech et al.¹

In their study, Bech and colleagues compared the effects of tissue cooling using an automated continuous-cooling device (CCD) with that of using intermittent ice packs (IIPs) following total knee arthroplasty (TKA).¹ The effects of experimental cold on human skin and subcutaneous tissues have been well studied;² less known are the effects of cryotherapy after hurt to deep soft tissue and joint structures.³ Reducing bleeding, pain, swelling, and secondary hypoxic injury are commonly cited as reasons for applying cold after trauma. These effects supposedly lead to reduced narcotic use; greater compliance with exercise programmes, which should produce increased joint mobility (ROM); and overall better rehabilitation outcomes. However, systematic reviews have concluded that there is only very weak to weak evidence supporting the use of cryotherapy following soft-tissue injury, that cryotherapy-mediated pain reduction does not necessarily translate into reduced narcotic use or increased ROM, and that cryotherapy does not improve long-term rehab outcomes.⁴ Yet health professionals still widely use ice for soft-tissue injuries—in homes, on sports fields, in hospitals, and in rehab clinics.

What could explain the disparity between the expected benefits of cryotherapy and the results of clinical trials? A primary consideration is how treatment is applied, but the existing evidence is inconclusive with respect to both the ideal cryotherapy method and what temperature reductions should be achieved. Chesterton, citing earlier authors, reported that skin temperatures below 13.6°C produce localized analgesia. Normal skin temperature around the knee is about 30°C, meaning that a decrease of about 17°C from normal would be required to produce local analgesia at the knee. Chesterton also mentioned reducing tissue temperature to <12.5°C to reduce nerve conduction velocity and to 10–11°C to reduce enzyme activity.² It is thought that decreasing intramuscular temperatures by 7–8°C reduces blood flow and metabolic requirements.⁵

While many cryotherapy studies involve only healthy tissues, Okcu and Yercan established that superficial cooling effects were very similar for healthy tissues and sprained ankles.⁶ Dykstra found that 20-minute wetted-ice bags (i.e., with ice starting to melt) applied directly to skin overlying gastrocnemius muscle reduced skin temperature and temperature at 2 cm muscle depth by about 17°C and 6.0°C, respectively.⁷ Crushed-ice bags (CIB) produced similar results at 1 cm depth in gastrocnemius (i.e., in the superficial part of the muscle).⁸ Using external wrapping to compress cooling bags against the skin has been shown to increase cooling effectiveness.⁹ Treatment duration is also a key factor: Rupp's group found that the majority of participants required 30–40 minutes of CIB that included external wrapping to achieve temperatures thought to produce the desired physiological effects at 1 cm muscle depth.⁵

It is questionable whether the temperatures cited by Chesterton can be achieved in deep tissues around the knee joint in everyday clinical practice.² Clinicians usually apply a protective layer between skin and cooling agent to prevent skin burns, and the resulting loss in cooling may be critical. Okcu and Yercan found that one layer of cotton padding wrapped with elastic bandage around the ankle reduced the amount of skin cooling produced by frozen ice packs.⁶ Similarly, in other studies, the

skin temperatures produced by a 20-minute gel pack applied to the thigh over one layer of towel also suggested that the towel reduced effectiveness.^{7,10} To what extent can absence of cryotherapy effects following soft-tissue injury be explained by the use of short-duration treatments, failure to compress the cooling agent against the skin, and inclusion of insulating material in the application?

The DonJoy ice pad is held in place using externally applied elastic bandage, which compresses the pad against a protective underlay (e.g., stockinet) and adds compression to control swelling; the pad is in contact with only the anterior and lateral knee surfaces, however, and in this respect it mirrors ice-bag techniques. Because the ratio of skin surface to tissue volume in ice application is an important factor affecting cooling, cryotherapy could potentially be more effective when ice bags or cooling pads encircle entire joints. Physiotherapists who provide postoperative TKA care are no doubt familiar with the extensive swelling that develops behind the knee.

Bech and colleagues' study is important for showing that a CCD provided no advantage over ice packs used in the usual manner at their facility.¹ Although the two approaches produced similar results, it is still worth considering whether IIP effects could have been enhanced. The investigators tried to standardize care by using an elastic bandage underlay to control knee swelling in the IIP group, but the insulating effect of the bandage may have reduced potential IIP cooling relative to the stockinet layer used under the CCD. Furthermore, it is not clear whether IIP was applied for long enough to reduce deep-tissue temperature, because usage was reported as percentages of the day and night rather than actual treatment duration and number of sessions; Myrer showed differences in intramuscular cooling using 10- versus 20-minute ice packs applied directly to skin (3.9°C vs. 7.0°C).⁸ Nevertheless, despite using continuous cooling and external pad compression, the CCD in Bech and colleagues' study produced modest reductions in skin temperature (an estimated 2–6°C).¹ It may be that pain and swelling are not addressed by mild skin cooling when deep tissues and joint structures are the main tissues involved.

Bech et al. suggest some reasons for CCD subjects' being more satisfied and compliant.¹ IIP patients apparently seldom requested IIP at night, and their daytime use was low, yet this group reported that they would have liked more frequent IIP. This finding may reflect patients' reluctance to ask nurses for assistance; the CCD enabled patients to receive cryotherapy more independently. A CCD would be particularly enabling at night, because treatment could be delivered without disturbing sleep. Notwithstanding possibly sub-optimal use of IIP and the fact that neither IIP nor CCD fully encircled the knee joint, the two methods produced similar outcomes.

There still remains the question of whether optimal use of either CCD or IIP during the 48-hour period after TKA is beneficial. Controlled trials and systematic reviews do not show convincing benefits for cryotherapy over placebo cooling. Do we need more studies comparing CCDs versus IIPs, wetted-ice versus CIB, and so on, when the evidence shows that different agents produce largely similar outcomes? Perhaps it is time to reconsider indications for cryotherapy. Indeed, some authors have

argued that cryotherapy is not indicated after trauma because cold prolongs bleeding and therefore delays haemostasis, and, furthermore, that blunting inducement of stress proteins may be detrimental to normal tissue repair.¹¹

Further research is needed to address cryotherapy usage. Future device studies should include placebo groups using pads filled with room-temperature water, both to determine whether there is any role for cryotherapy after deep-tissue injury and to enable blinding of investigators. In addition, cryotherapy applications should be designed to optimize temperature reductions in deep tissues.

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