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Topical Refrigeration and Frost Anesthesia

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THE NUMBING effect of cold has been a ripple in mankind's pool of knowledge ever since our forebears were nudged southward by the glacial advance of the Pleistocene epoch. Cold probably preceded even pressure on nerves as a surgical anesthetic. Hippocrates of Cos (*ca.* 460–377 B.C.) is said to have used ice and snow applications before beginning operative work.[1] Avicenna, Persia's Prince of Physicians (A.D. 980–1070), in his Canon of Medicine referred to snow and ice-water as being among "the less powerful narcotics."[2]

Probably the first man in Christendom to pass on a detailed technique of surgical anesthesia using refrigeration was Marco Aurelio Severino (1580–1656), anatomist and surgeon of Naples. Severino's technique was recorded by his student, Thomas Bartholinus, the Elder, in *De Nivis Usu Medico*[3] (fig. 1).

"This I was taught at the Gymnasium in Naples by Marcus Aurelius Severinus, my teacher and friend . . . he applied snow in a small tube . . . he told us that after the medicine had been applied in narrow parallel lines, and after the feeling had been rendered insensitive, [that] it was permissible to cut the place which was free of pain. . . ."

He further advised that the procedure was made even more astonishing to the patient if the snow was colored with dyes.

Dominique-Jean Larrey (1766–1862), Napoleon Bonaparte's celebrated military surgeon recounted the anesthetic effects of exposure to freezing battlefield conditions in his memoirs; the −19° C. temperature allowed him to perform painless amputations on the half-frozen soldier-patients.[4]

Nathaniel Ward, a pupil of Sir James Paget, described how he helped Paget remove a large lipoma of the back under salted ice anesthesia. Mortimer Cranville used a freezing mixture to relieve pain attendant to parturition.[5]

In 1847, James Arnott described an apparatus by means of which cold could be applied to selected areas (fig. 2),[6] a modification of

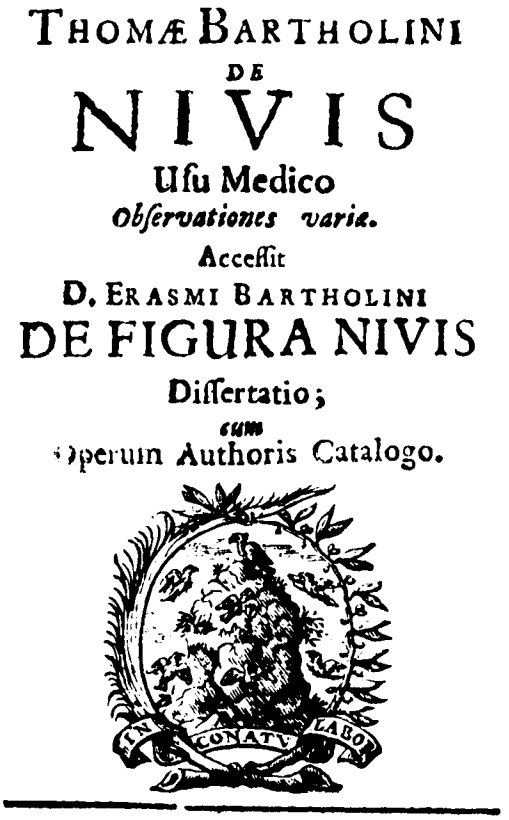
THOMÆ BARTHOLINI
DE
NIVIS
Uſu Medico
Obſervationes variæ.
Acceſſit
D. ERASMI BARTHOLINI
DE FIGURA NIVIS
Diſſertatio;
cum
Operum Authoris Catalogo.
IN CONATV LABOR
HAFNIÆ, L.
Typis Matthiæ Godicchii,
Sumptibus PETRI HAUBOLD, Bibl.
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FIG. 1. Title page of Bartholinus' *De Nivis Usu Medico* (On the Medical Use of Snow) which described Severino's technique of refrigeration anesthesia.[3]

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which was successful in producing surgical anesthesia[7]:

"To benumb a small portion of skin, a very simple apparatus is required. A small pig's bladder, some pounded ice, and a little salt. The bladder, containing tepid water, is placed so as to cover the portion of skin to be rendered insensible; the ice is then gradually dropped in, and last of all the salt so as to bring the temperature considerably below the freezing point. . . . when all sensation has ceased, which I have generally found to be the case after 15 or 20 minutes, the operation should be proceeded with."

Arnott won a gold medal in the Great Exhibition held in Hyde Park in 1851 for "a mode of applying cold as a therapeutic agent."[8]

In 1852, von Langenbeck reported the use of ice as a means of local anesthesia for performing uranoplasties.[9] Sigmund Freud's work with cocaine[10] which came to fruition with Carl Köller's development of topical anesthesia for ophthalmic surgery[11] revolutionized the concept of local anesthesia and diverted attention from the use of ice and snow.

However, a renascence of interest in the application of ice occurred at the time of World War II. The Russians utilized local refrigeration during the Russo-Finnish campaign of 1939–1940.[2] In the United States, the latter-day pioneer of refrigeration anesthesia was F. M. Allen, an internist whose interest was kindled by attempts at treating diabetic gangrene with refrigeration. He developed the technique of applying an ischemia-producing tourniquet around the thigh to increase the cooling depth and efficiency.[12] The technique was particularly effective in compromising circumstances and gained popularity for amputations in military field hospitals. In 1943, Mock[13] used ice bags to furnish surface anesthesia for removal of split skin grafts from the thighs. In 1951 Gibson developed a motor driven refrigeration device to anesthetize donor sites for skin grafts.[14]

We must return to the mid-nineteenth century to pick up the remaining chain of thought in the history of frost anesthesia, which is the development of volatile refrigerants. The eminent success of the general anesthesia which Long,[15] Morton,[16] and Simpson[17] produced with ether and chloroform stimulated widespread investigation of the *local* anesthetic

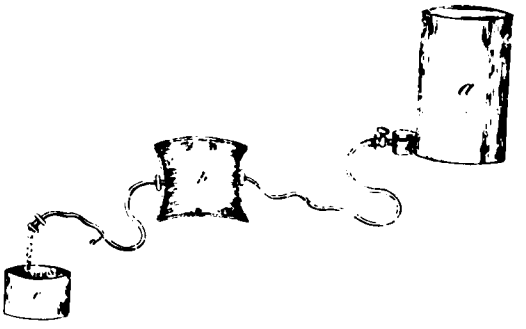

FIG. 2. Arnott's Original *Current Apparatus*.[6] The reservoir *a* contained a mixture of salt, water and ice. The cushion *b* was held against the part to be cooled.

effects of these and other volatile organic liquids.[18, 19] Some reports indicated a certain measure of success in producing topical local anesthesia. This is doubtless what led S. L. Hardy[20] to try a fine spray of chloroform directed through a vaginal douche (fig. 3) for the treatment of pelvic pains encountered in his gynecological practice. He reported dramatic results, *e.g.*, a 25 year old woman with "lumbar, uterine and breast pains" was relieved in one minute after "two or three jets." His report in the *Dublin Quarterly Journal* was read widely, and his device was demonstrated in Paris. Parisian physician, Guerard, enlisted the engineering skills of Mathieu to modify the original idea, and to construct an effective device consisting of a hand driven compressor which delivered a jet of ether and a current of air to the operative site (fig. 4). The evaporating ether caused a rapid drop in temperature and local anesthesia was quickly established. Guerard presented his device to Richet, a surgeon at Hôtel Dieu for trial. Richet successfully removed a mandibular tumor,[21] did a number of small procedures,[22] and disarticulated a toe.[23] He

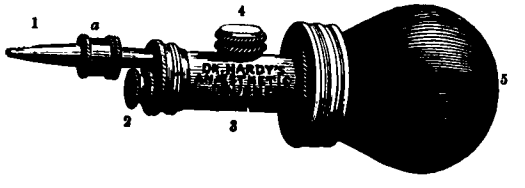

FIG. 3. Hardy's *Anaesthetic Douche* which delivered a fine spray of chloroform intravaginally to treat pelvic pain.[20]

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a eu l'heureuse idée d'adopter au ventilateur un petit appareil à irrigation d'éther, de telle manière que l'irrigation et l'insufflation se font tout à la fois sur les mêmes points. La figure ci-jointe fera suffisamment connaître le jeu de cet appareil. A est un réservoir à pression continue dans lequel on verse l'éther et dont un piston à ressort le fait passer en jet très fin par l'extrémité de la canule B.)

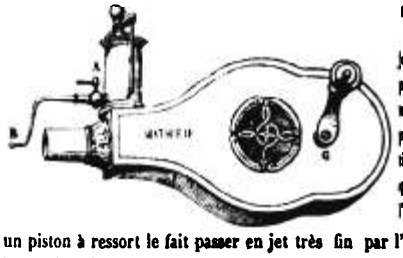

FIG. 4. Guerard's device for delivering a spray of ether and compressed air to the skin for surgical anesthesia.[22]

even drained a paronychia on his own finger with Guerard's device.[24] Richet believed that the anesthesia was due to a local pharmacologic action, but Guerard was convinced that refrigeration was the basis.[25] Richardson produced a similar device twelve years later, apparently without knowledge of Guerard's work.[26] He achieved some acclaim through this and other investigations, and thereafter, refrigeration by ether spray was often called Richardson's method.

In 1880 J. B. Rottenstein [27] reported the use of ethyl chloride as an effective local anesthetic but did not clarify whether he used it as a topical application or a refrigerant spray; presumably it was the latter. Redard in 1891 reported the definite use of a refrigerant spray of ethyl chloride in minor surgical procedures with excellent results,[28] and the technique persists to the present day. Wilson *et al.*,[29] seeking to overcome the dangers of inflammability and hepatotoxicity which accompany ethyl chloride, introduced the use of dichlorotetrafluoroethane (Freon 114) as a refrigerant anesthetic for use in dermabrasion, and this is now the standard refrigerant for dermabrasion. The basic cause of the anesthetic effect of cold is nebulous, but recent work suggests that reduced temperatures cause a molecular rearrangement of body water with resultant electrical impedance, or else short circuiting of the nerve impulses.[30, 31]

FIG. 5. Delivery of dichlorotetrafluoroethane spray from two hand held containers. Graft is being cut from frosted skin with Brown dermatome.

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Our first chain of thought ended with the grafting of skin. Similarly the most recent link in the application of volatile refrigerants has been the development of frost anesthesia for the cutting of skin grafts. Freon 114 is currently used to lay down a light frost in the path of the dermatome, allowing an unlimited quantity of skin to be cut without the need for a general anesthesia.[32] Survival of the skin grafts is not affected by the frost (fig. 5).

Summary

The history of topical refrigeration and frost anesthesia is reviewed, starting with Hippocrates, and ending with frost anesthesia for skin grafts.

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