Nerve Supply of the Breast With Special Reference to the Nipple and Areola: Sir Astley Cooper Revisited

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Cooper in 1840 described mammary branches from the 2nd–6th intercostal nerves, and noticed that the nipple was supplied by branches which lay close to the surface of the gland. Eckhard (1850) divided the mammary branches into superficial branches to the skin and nipple, and deep branches to the glandular tissue and nipple, but many later authors ignored those findings. After the second World War, cosmetic surgery of the breast made further research critical, as surgeons strove to design operations which would retain its shape and preserve postoperative sensation. Craig and Sykes (1970) described mainly anterior branches from the 3rd, 4th and 5th intercostal nerves passing through the glandular tissue of the breast and along the line of the ducts to the nipple, while Farina et al. (1980) concluded that the nipple was supplied solely by superficial lateral branches of the 4th nerve. Using improvements in dissecting technique learned from microsurgery, Sarhadi et al. (1996) found that the nipple was innervated by the lateral cutaneous branch of the 4th intercostal nerve, by two branches, one passing superficial to the gland, and the other through the retromammary space, and by variable lateral and medial additional branches from the 2nd–5th nerves. These branches came to lie superficially and formed a subdermal plexus under the areola. This account is uncannily close to Cooper’s original description: it is a reassuring, if sobering, conclusion that his early account remains one of the most reliable. Clin. Anat. 10:283–288, 1997.

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EARLY ANATOMICAL OBSERVATIONS

Sir Astley Cooper published a detailed account, "Of The Nerves of The Breast" in his monograph, "The Anatomy of the Breast" (Cooper, 1840), describing the nerves supplying the breast in detail and tracing those that innervate the nipple. One of his original illustrations is reproduced here as Figure 1. The nerves are indicated by small numbers to the left of the plate, the numbers corresponding to those of the intercostal nerves in current practice. Cooper observed that from the 2nd to the 6th intercostal nerves, the mammary branches arose both on the lateral side and the medial side of the breast. He named the mammary nerves arising from the lateral cutaneous branches as "direct nerves" and described them thus: "The dorsal direct or posterior nerve going to the breast. 1, Is the first nerve going to the pectoral muscle. 2, The second nerve passing to the external mammary artery, this nerve in the subject before us sent a large branch to the mammary gland descending in the course of the arteria thoracica longa. 3, The third nerve passing to the external mammary artery. 4, The fourth nerve dividing into two branches, the upper branch passing on the external mammary artery to the breast; the lower branch proceeding upon the surface of the breast to the nipple. 5, Passing to the gland of the breast and to the base of the nipple, joining the fourth. 6, In this subject two nerves, the upper going to the vessels below the breast, the lower to the skin below it. 7, The seventh is distributed much below the breast." Cooper also described anterior branches from the 3rd to the 5th intercostal nerves as supplying the breast and called them "reflected nerves." The branch from the second supplied the chest wall above the breast and that from the sixth below it.

In his dissections, Cooper (1840) found that nerves to the nipple arose from the lateral cutaneous branches of the 4th and 5th intercostal nerves and the anterior...
cutaneous branches of the 3rd and 4th intercostal nerves. All of them passed close to the anterior surface of the gland, and the lateral branches from the 4th and 5th nerves formed a plexus at the base of the nipple and areola and were distributed to the nipple along with branches of arteries. Cooper paid particular attention to the mammary branches from the 4th intercostal nerve: of its lateral cutaneous branch he wrote, "The fourth dorsal nerve appears just below the fourth rib, emerging through the intercostal space from the inner part of the chest. It almost immediately divides into two nerves; the upper branch passes to the external mammary artery, and descends with it to the upper part of the mamma. The second branch passes upon the surface of the breast and advances to the basis of the nipple, where it divides into branches which supply its papillae." (Cooper, 1840) He also described the anterior cutaneous branch of the 4th as "divided into two branches which passed through separate holes; the first proceeded upon the surface of breast to the basis of the nipple, the second to the upper and inner part of the gland of the breast." (Cooper, 1840)

Eckhard (1851), using magnifying lenses and histology, described the nerves supplying the skin of the breast as coming from the 2nd–6th intercostal nerves, and found that several of them innervated the nipple. He also noted that the nerves from the lateral cutaneous branches of the 4th–6th, one, two or three in number, supplied the glandular tissue of the breast and terminated around the milk ducts under the nipple. His main interest was the nerves supplying the gland itself and their influence on the secretion of milk. We know today that the somatic sensory nerves play no role in milk secretion, which is under hormonal control, although the ejection of milk depends upon reflex release of oxytocin, effected by stimulation of the nipple by sucking.

Cooper and Eckhard were both ardent dissectors, who struggled to trace these fine nerves to their final distribution, but for over a century and a half, their findings were not included in textbooks of anatomy. In Quain's Elements of Anatomy (Sharpey et al., 1878), the nerves supplying the breast "proceed from the anterior and middle intercostal nerves." In Ellis's Demonstrations of Anatomy (Addison, 1905) the breast was innervated "from the anterior and lateral cutaneous branches, nerves of the thorax, viz. from third, fourth and fifth intercostal nerves." Brash and Jamieson (1943) wrote that the nerve supply of the skin of breast was derived from the 4th, 5th and 6th intercostal nerves. As for the nipple, most textbooks paid little attention to its nerve supply or made rather specious comments about the quality of sensation. For example, Wood Jones (1946) suggested that sensation in the nipple "resembles in its high threshold, all-or-none, type of response and in quality, the protopathic type of sensation present during recovery following division of a peripheral nerve."

ESTHETIC BREAST SURGERY

With the rapid development of plastic surgery since World War II, an increasing number of women have undergone reduction mammoplasty and this has revived interest in the sensory nerve supply of the nipple and areola and its survival following reduction surgery (see, e.g., Craig and Sykes, 1970; Townsend, 1974; Courtiss and Goldwyn, 1976; Terzis et al., 1987; Slezak and Dellon, 1993; Gonzalez et al., 1993).

Craig and Sykes (1970) not only tested sensation of the nipple and areola after various types of reduction mammoplasty, but also made cadaveric dissections of the nerves supplying the nipple and areola. Their diagram (Fig. 2) is familiar to every breast surgeon. They believed that the nipple and areola were supplied by branches from the anterior cutaneous branches of the 3rd, 4th and 5th intercostal nerves, with additional nerves from the lateral cutaneous branches of the 4th and 5th nerves regularly, and from the 3rd intercostal nerve in six out of twenty specimens. However, their findings disagreed with those of Coo-
Cra{ger} (1840) on the course and distribution of the nerves, maintaining that, "No branch either of the anterior or lateral series of intercostal nerves was found passing superficial to the breast tissue to reach the nipple. The nerve tended to stay close to the layer of deep fascia on the anterior surface of pectoralis major muscle..." (Fig. 2). They also observed that, "Small proximal branches pass through the subcutaneous tissues to reach the skin over the breast (never the nipple), and other more distal branches pass through the gland and subcutaneous tissues to reach the periareolar skin. Terminal branches pass to the nipple closely related to the fibrous septa (ligaments of Cooper) and follow the line of the ducts towards the nipple."

These descriptions of Craig and Sykes (1970), though familiar and influential, have been difficult to reconcile with clinical findings after operation. Clinical evidence suggested that the nipple retained sensation even when the breast was reduced by resecting the central part of the gland from under the areola as reported by Regnault (1974) and Lejour (1994), or when the nipple itself was transposed on a dermal pedicle using techniques popularized by Strombeck (1964) and McKissock (1971). Surgical dissections in these procedures would have divided the nerves supplying the nipple had these run through the breast as described by Craig and Sykes (1970).

Farina et al. (1980) were encouraged by the results of sensory tests after mammaplasty to return to the dissecting room. They found that the course of the nerve to the nipple lay near the surface of the breast, confirming the observations of Cooper (1840) and refuting those of Craig and Sykes (1970). Farina et al. (1980) concluded that only the 4th nerve supplied the nipple, mainly through its lateral cutaneous branch, which entered the breast in its inferolateral part, as shown in Figure 3, reproduced from Gonzalez et al. (1993). This observation of a single supplying nerve appears to conflict with reports by Terzis et al. (1987) and Cathcart et al. (1948) that the nipple is highly sensitive and has a rich nerve supply, but supported the opposite view (see, e.g., Courtiss and Goldwyn, 1976), that there are few nerves supplying the nipple and it has poor sensation. Farina et al. (1980) recommended keeping the inferolateral part of the breast in continuity with the nipple in order to preserve sensation in the nipple. This view was confirmed in a series of breast reductions reported by Bolger et al. (1987), and by Gonzalez et al. (1993). These anatomical findings did not, of course, explain why, in a high proportion of breast reductions, sensation in the nipple is retained even when it has no anatomical connection with the inferolateral quadrant of the breast, as reported by Skoog (1963), McKissock (1971), Orlando and Guthrie (1975), and Robbins and Hoffman (1992). These authors used either superiorly based pedicles or dermal pedicles for breast reductions.

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**Fig. 2.** “A diagram illustrating the typical course and distribution of the nerves innervating the nipple.” Reproduced from Craig and Sykes (1970) with kind permission of the Editor, British Journal of Plastic Surgery. The nerve is shown passing through the thickness of the breast tissue, and running alongside the lactiferous ducts.
RECENT DEVELOPMENTS

The widely differing results from anatomical dissections of nerves supplying the breast as reported by Cooper (1840), Eckhard (1851), Craig and Sykes (1970), and Farina et al. (1980) may indicate variable anatomy, or, perhaps more likely, may result from differences in technique. Craig and Sykes (1970) did not use magnification when dissecting the nerves supplying the nipple and areola and it is difficult to differentiate the terminal nerves to the nipple when they are closely related to the fibrous septa and run along the ducts. They may have lifted the nerves in the periareolar area along with the skin flaps and were therefore only able to trace the peripheral nerves to within a few centimeters of the areola. Farina et al. (1980) did not mention having used magnification, and in any event, they concentrated their attention solely on the 4th nerve and did not follow the other nerves to their destination in the breast. None of the authors examined the "nerve tissue" histologically.

In our own anatomical study (Sarhadi et al., 1996), the nerves to the breast were traced using magnification and techniques of dissection practised during microsurgery. Fine branches of "nerve" were checked histologically. This investigation confirmed that the breast received innervation from the lateral and anterior cutaneous branches of the 2nd-6th intercostal nerves, along with a contribution from the supraclavicular nerves. Mammary branches passed mainly through the superficial fascia on the anterior surface of the gland, but there were additional branches to the nipple from the 4th and, occasionally, from the 5th lateral cutaneous branch, which passed through the posterior layer of superficial fascia, behind the gland (Fig. 4). These additional branches also appeared eventually on the anterior surface of the gland, in the inferolateral part of the breast. The nipple and areola received nerve supply with a varying frequency from the lateral and anterior cutaneous branches of the 2nd-5th intercostal nerves which joined a plexus in the subdermal region. The nerves supplying the breast communicated freely and converged towards the areola from all directions (Fig. 5). These findings explain why the nipple and areola retain sensation in a majority of cases even when a central core of breast tissue is excised or a reduction is carried out using a superior or inferior pedicle.

CONCLUSION

The findings of Sarhadi et al. (1996) are uncannily like those of Cooper (1840) who described the nerves
supplying the breast as arising from the 2nd–6th intercostal nerves, with mammary branches passing on the surface of the gland and intercommunicating. He also described the two mammary branches from the 4th lateral cutaneous nerve and mentioned that the nipple receives its innervation through a plexus under it. It is a reassuring, if sobering, conclusion that the description of breast innervation given 155 years ago by Sir Astley Cooper, a surgeon anatomist in the Hunterian tradition, is apposite to today's clinical practice.

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REFERENCES


