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Problem Analysis in Reconstructive Surgery: Reconstructive Ladders, Elevators, and Surgical Judgment

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HISTORY OF RECONSTRUCTIVE SURGERY

As one of my professors, the late Bradford Cannon, noted, the field of plastic surgery, unlike most other surgical specialties, has no anatomic or functional area to which it can lay claim; the plastic surgeon practices methods and techniques applicable to all specialties and anatomic areas. Plastic surgery as a specialty was based on, and continues to be defined by, the process of developing creative solutions to the most difficult and challenging problems everywhere in the human body – literally from the head to the toe. As such, the plastic surgeon of today is, in fact, the last true "general surgeon." Though plastic surgery is comprised of two distinct "spheres," reconstructive surgery and aesthetic surgery, the two are closely intertwined and have great overlap. Many of the techniques employed in modern aesthetic surgery have their basis in reconstructive surgery. Similarly, reconstructive surgery focuses on restoring both function *and* form, such that many techniques used in aesthetic surgery are also employed in modern reconstructive surgery, such as flap contouring, fat grafting, etc.

Reconstructive surgery is the process of restoring the human body to "whole" following tumor extirpation, infection, trauma, or congenital or acquired deformity – restoring both form and function. Because the result of tumor, infection, trauma, or deformity has such a major effect on a patient's life, health, and well-being, reconstructive surgery can have the powerful effect of truly rebuilding a patient's life. The professional and personal gratification this brings to the reconstructive surgeon is profound.

Clearly, not all reconstructive surgery is performed by plastic surgeons. Indeed, orthopedic surgeons, otolaryngology/head and neck surgeons, oral surgeons, ophthalmologic surgeons, urologic surgeons, pediatric surgeons, gynecologic surgeons, and general surgeons perform a great deal of outstanding reconstructive surgery. But what they all have in common in performing reconstructive surgery is that all follow the same goals and principles of restoring both form and function.

The techniques employed in reconstructive surgery have come a long way from the days of Tagliacozzi, reconstructing noses with pedicled flaps from the arm, in the 1500s. Yet, only 50 years ago, those same techniques of random pedicled flaps still formed the basis of much of reconstructive surgery. In the 1930s, split skin grafts came into regular use, and in many ways defined the specialty of plastic surgery at its origin.[1] Over the past 50 years, there has been an explosion in the development of reconstructive techniques and approaches. In the 1960s, it was recognized that designing a flap based on an axial vessel could greatly increase the viable length of the flap to include the entire length of the axial vessel, plus a random component distal to it. This led to McGregor's description of the forehead flap in 1963 and Bakamjian's description of the deltopectoral flap in 1965.[2,3] Then, the introduction of the two-headed operating microscope in 1960, and Buncke's pioneering laboratory work in the early 1960s, including his rabbit ear replantation in 1964, opened the door to microvascular surgery.[4,5] The first clinical application of the operating microscope was in replantation, with Konatsu and Tamai's successful complete thumb replantation.[6] The first microvascular composite tissue transplantation in a human was a second toe to thumb transfer, by Yang and Gu in 1966.[7] In 1972 McLean and Buncke performed a free microvascular omental flap to cover a cranial defect, and the following year, both Daniel and Taylor performed the first free cutaneous flaps – free groin flaps, and thus the microsurgery revolution began.[8,9]

THE RECONSTRUCTIVE LADDER

In the 1970s, Mathes and Nahai,[10] as well as others, introduced the concept of muscle and myocutaneous flaps that had a tremendous influence on reconstructive choices throughout the body – head and neck, trunk, as well as upper and lower extremity. In their two seminal textbooks, first an atlas of muscle and myocutaneous flaps in 1979, then a text on clinical applications in 1982,[11] they defined

and laid out the clinical application of these flaps in an anatomically-based manner with the goal of providing a complete algorithm of whole body reconstruction. In the latter text, they also described the concept of a "reconstructive ladder," which was a principle-based algorithm of reconstructive choices, based on Occam's Razor – the simplest solution is the best – whereby the entire spectrum of reconstructive options, including the vast variety of options developed in recent years, formed rungs of a ladder, with the simplest options at the bottom of the ladder and the most complex options at the top rung of the ladder.

According to this concept, one would choose the simplest form of reconstruction that would serve to solve any particular reconstructive problem. For example, primary closure would form the first rung of the ladder, and, if feasible, should be the reconstruction of choice. Farther up the rungs would be closure by secondary intent (i.e., wound contracture), skin graft, local flap, distant flap, and at the top, free flap. The concept was beautiful in its simplicity, and had an immediate and lasting effect on reconstructive decision to this day. But, to quote Albert Einstein, "Everything should be made as simple as possible, but not simpler." In the quest to provide a simple algorithm for reconstructive surgery that could be applied throughout the human body, a number of nuances were overlooked, and with the growing plethora of reconstructive options in the next few decades, the "reconstructive ladder" was soon in need of some "reconstruction."

THE RECONSTRUCTIVE ELEVATOR

The reconstructive ladder has since come under criticism for its focus on simplicity in wound closure, without explicitly highlighting the importance of form and function in the final outcome. In 1994, Gottlieb wrote that the simplest is not necessarily always the best, and that reconstructive surgery calls for "creative parallel thought rather than simple sequential thought." He proposed the concept of a "reconstructive elevator," whereby one would not simply choose the simplest technique that could achieve wound closure, but should instead ride the reconstructive elevator, bypassing simpler reconstructive methods that may not achieve the best outcome in terms of form and function, up to the most appropriate reconstructive method for the individual situation, even if it meant choosing a more complex method.[12] The two editors of this text, and others, have similarly called for a "reconstruction of the reconstructive ladder" with the goal of focusing on the optimum method of reconstruction, rather than merely the simplest.[13,14] At its inception, the reconstructive ladder was never meant to be a rigid algorithm, confined to choosing the simplest method possible, but instead was merely a framework to consider all of the various reconstructive options available, in light of their cost/risk and benefit (Foad Nahai, MD pers. comm. 2014). In the end, everyone who has considered this question is really saying the same thing. The true principles therefore are:

- Do not merely use the simplest technique possible; use the simplest technique that will achieve optimal form and function.
- Do not be afraid to choose a complex reconstructive method, if it will provide the best long-term outcome.
- Not everything needs a free flap.
- Base the choice of reconstructive method on the quality of the reconstruction in terms of type of tissue, shape, contour, durability, and function; not the mechanics of the reconstruction, whether it be skin graft, random flap, pedicle flap, or free flap.
- Consider the individual patient's problem, needs, health, risks, and long-term outcome, and tailor the reconstructive choice to the patient and the problem.

Some examples of these principles include facial reconstruction and pressure sore reconstruction. In most facial tumor resection defects, although a skin graft might suffice to close the wound, a local flap is almost always preferable, in terms of both form and function and also contour and aesthetics, and is often just as simple to perform. In a pressure sore reconstruction, although primary closure or a skin graft may be simplest, neither has the durability of a myocutaneous flap. One must choose the best reconstruction to achieve optimal, long-term form and function, and balance that with the complexity of the reconstruction, patient needs and overall health, and, in the current medical environment, what provides the best value to the patient and society.

SURGICAL JUDGMENT

THE PRESENT STATE OF RECONSTRUCTIVE SURGERY

In the end, problem analysis and surgical planning in reconstructive surgery come down to exercising one's best surgical judgment. But, as Mark Twain said, "Good judgment is the result of experience, and experience the result of bad judgment." Hopefully, those practicing reconstructive surgery will have taken advantage of the experience of their mentors during their training, and texts such as this, evidence-based outcomes studies in the literature, and at professional meetings, as well as the experience of colleagues and mentors in their daily practice, when selecting the most appropriate reconstructive option for the particular case at hand.

Surgical judgment in reconstructive surgery involves first analyzing the clinical problem, whether it be tumor, infection, trauma, or deformity, then determining what steps need to be taken to set the stage for an optimal reconstruction. If it is tumor, then complete resection is paramount to achieving a successful reconstruction. Similarly, with infection or trauma, excisional debridement, as with a tumor resection, back to healthy, well-vascularized tissue is critical before beginning reconstruction. If it is a deformity, then complete release or removal of scarred, contracted, or deformed tissue must be performed first. Sometimes this requires a staged approach to reconstruction, awaiting final pathology margins for a tumor, or ensuring that a trauma debridement removed all non-viable tissue.

Next is the critical step of choosing the best reconstructive approach. Here, one must begin by assessing what components are missing; what the functional requirements