Cutting to Cure to Cutting Down the Incision: From Kindest Cut to Virtually No Cut

The evolution of surgery is truly an astounding narrative. The word surgery, derived from the Greek word “Chirugia,” meaning handwork, is one of the earlier arts acquired by humanity as evidenced by the cave paintings from the Neolithic period. Archaeological excavations near the Indus Valley dating back to the early Harappan period revealed that operations on the skull and teeth were performed during that time. Significant contributions from notable surgeons of ancient Greek, Roman, Egyptian, Babylonian, and Indian civilizations refined the surgical knowledge. However, the two major obstacles in the form of pain and surgical infections made any surgery a traumatic and painful procedure. These problems were highlighted by one of the famous cases of Robert Liston, a famous Scottish Surgeon, who amputated the leg of a patient in ≈ 3 min to shorten the duration of pain. The movement with his knife was so rapid that he amputated the fingers of his young assistant and the knife went through the coat tails of an elderly surgical spectator. Both the patient and the assistant died of sepsis secondary to stump and digital gangrene. The elderly doctor, although not injured by the knife, collapsed on the floor on seeing himself covered in blood and thinking that the knife had entered his body, died of a heart attack. This only operation in the history of surgery with a 300% mortality highlighted the problems of sepsis and the need to perform rapid surgery to minimize the duration of pain. Probably, for the same reason, European universities, during the Dark Ages (350–700 AD), did not consider surgery as a physician’s job. Surgeons were forced to learn other skills such as magic, music, and even hair cutting to make a living. The term “barber-surgeons” highlights the ordeal faced by the surgeons who traveled around and carried out surgical procedures in different places in addition to hair cutting. The introduction of aseptic techniques by the British Surgeon Joseph Lister and anesthesia by Horace Wells and William Morton using nitrous oxide (laughing gas) in the early 19th century, turned forceful and traumatic operative approaches to relatively safe procedures. The iconic images of the operating theater of that period showing surgical procedures performed in front of students and members of the public sitting in small galleries soon changed to a modern operating room with a strict focus on asepsis. The development of electrocautery, staplers, and other newer tools helped surgeons to perform complex open surgical procedures, including organ transplantation. The early 20th century saw the turnaround wherein the probability of surviving surgery became greater than the chance of dying in the perioperative period. In the 1970s, when surgeons mastered the safe technique of open surgery, the focus shifted to reducing the size of incision which saw the introduction of laparoscopic, or minimally invasive surgery.

The advent of laparoscopic surgery is considered a true revolution in the field of surgery, as for the first time in the history of humanity the surgeon started operating on the patient without looking at the patient but by looking at the monitor. This enabled the surgeon to perform surgical procedures with one-tenth to one-twentieth of the incision size required for open surgery. The small incision reduced postoperative pain and facilitated early ambulation of the operated patients, thereby enhancing postoperative recovery and reducing hospital stay. Furthermore, small incisions avoided the cosmetic disfigurement associated with large incisions. However, it posed new challenges for the surgeons who seemed to have mastered the art of surgery. A surgeon who carried out open surgery, had the freedom of movement/rotation in 36 independent directions/axes using his interphalangeal, metacarpophalangeal, wrist, elbow, shoulder joints and by turning his whole body, was forced to operate with just 4 degrees of freedom. Damage to the vascular and other delicate structures due to the lack of tactile feedback resulted in bleeding-related complications during the learning phase. Lack of depth perception, an inherent drawback of the two-dimensional (2D) vision of laparoscopic surgery, resulted in a surgeon often stopping short or overshooting the target structure, especially when trying to grasp the needle or suture. The long narrow instruments of laparoscopic surgery gave the feeling of writing with the pen by holding it far away from the nib close to the other end. The poor mechanical advantage resulted in exaggerated tremors which made even the experienced surgeon look like a novice. Another challenge faced by the surgeon, especially the assistant surgeon, is decoupling of visual and motor axis, especially when the surgeon/assistant must turn around to look at the monitor. Compromised hand-eye coordination due to the fulcrum effect wherein the surgeon must move the instrument in the opposite direction from the target structure on the monitor to reach the point of interest posed an additional constraint. However, the inherent fighting spirit of the surgeon helped overcome the challenges posed to him. Various box models created to simulate laparoscopic surgery helped the surgeon overcome the mechanical and visual constraints of the laparoscopic surgery. Advanced simulators with haptic feedback helped trainees to practice and objectively evaluate the progress in their laparoscopic skills. The realization of the advantages of minimally invasive surgery and some of the limitations of laparoscopic surgery resulted in the emergence of robotic surgery.

The term robot is derived from the Czech word “robota” meaning forced labor. Before its use in the field of medicine,
the robots were primarily used in industries to perform repetitive tasks. With the advancements in technology, the passive robots used in industries evolved into highly intelligent anthropomorphic robots with significant autonomy. However, the current surgical robots resemble the initial industrial ones wherein they do not have any autonomy but work on the master–slave concept with the surgeon sitting in the master console controlling the movements of the robotic arms in the patient cart.[3] Robotic surgery has the potential to overcome some of the limitations of laparoscopic surgery. The robotic instruments with wristed articulation and seven degrees of freedom enhance dexterity. The tremor filtration technology wherein the movements of the surgeon’s finger at the master console are scaled down to micromotion at the patient end helps perform fine dissection. By eliminating the fulcrum effect, the robotic system restores hand–eye coordination. The 3D vision created by the image processor in the master console gives depth perception to the surgeon. More importantly, the camera is under the control of the surgeon which gives him a stable vision, especially when working in a confined space. The ergonomically designed workstation avoids the awkward positions sometimes encountered during laparoscopic surgery, thereby avoiding shoulder joint and cervical spine problems common with laparoscopic surgeons. Furthermore, it allows physicians to work remotely on patients from around the world as evidenced by the first transatlantic cholecystectomy performed in 2001 wherein the surgeon sitting in the console in New York operated on a patient in Paris. The two hospitals were connected by high-speed optical fiber so that the time delay was brought down to an impressive 66 ms. This opened new possibilities such as operating in remote areas or in battlefields. However, there are still some unanswered questions for robotic surgery.

The primary disadvantage with robotic surgery is the exorbitant cost when compared to laparoscopic surgery. Limited compatible instruments make it a challenge to perform a few surgeries such as liver surgery without the ultrasonic surgical aspirator. Furthermore, the large size of the current system requires a specially designed operation theater increasing the setup cost. Most importantly, it is still not clear whether increased costs translate to clinical benefits. Majority of the studies failed to show a significant advantage in perioperative outcomes with robotic surgery in comparison with laparoscopic surgery in hysterectomy, colectomy, or prostatectomy.[4] Furthermore, inferior outcomes with more genitourinary complications were reported during the early adoption time for robotic prostatectomy, highlighting the need for a formal robotic training curriculum. However, the problem associated with the learning curve was reported even with laparoscopic surgery. As of now, robotic surgery is not recommended as a superior option compared to laparoscopic surgery to perform minimally invasive surgery. However, as said by Arthur Schopenhauer, all truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident. Laparoscopic surgery went through the three stages and that will probably be true for robotic surgery. If the cost of robotic surgery becomes comparable to laparoscopic surgery, it has the potential to shorten the learning curve associated with complex minimally invasive surgery and encourage more surgeons to adopt the approach.

As a surgeon, it is important to understand the evolution of surgery and learn new technology. Experts in the field should focus on generating high-quality evidence related to various surgical approaches. Only when the surgeon is trained in different surgical approaches, he/she would be able to choose the right approach for a patient. Resistance to learning new technology would result in biased decision-making. It is the duty of a surgeon to learn and encourage residents/fellows to undergo training in various surgical approaches to provide quality, evidence-based patient-centered care.

References
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