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ADVANCES IN TRANSLATIONAL SCIENCE

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Endoscopy 20 Years Into the Future

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Gastrointestinal endoscopy has had a spectacular run in the last few decades with advances in technology that have redefined both gastroenterology and gastrointestinal surgery. Going forward, its contributions are likely to be even more meaningful as new procedures expand both the indications as well as the user base and contribute to bending the curve of healthcare costs. In this essay, I will describe some of what I believe to be the most important future developments with the greatest potential for impact across the spectrum of digestive disorders.

Keywords: Gastrointestinal Endoscopy; Colonoscopy; Capsule Endoscopy; Laparoscopic Surgery.

Making a prediction about virtually anything is an exercise fraught with danger, and it was with considerable trepidation that I accepted the kind invitation by the editors of this journal to write another commentary about our "endoscopic future."[1,2] Easing my anxiety somewhat was that even if I am completely off the mark, few people, if any, will remember what I have written 20 years from now! As an aside, 20 years also happen to be about the same period of time that I have been practicing gastroenterology. In this article, I hope to extract some lessons I have learned during this period from my own personal efforts at innovation as well as from observing the brilliance and entrepreneurship of the many talented colleagues from whom our specialty has been so fortunate to benefit. For the most part, I will confine my remarks to broad themes and platforms rather than focus on individual technological embodiments.

A Brief Look Back

Before embarking on a journey into the future, it may be instructive to examine where we were 20 years ago. In 1992, the first videoendoscopes were beginning to be introduced and widely hailed as one of the most important breakthroughs in our field. At the same time, surgeons were scrambling to adopt what was viewed as a consumer-driven revolution in their field, laparoscopic surgery. Endoscopic ultrasound was an exotic tool whose utility had yet to be established, and capsule endoscopy would have been dismissed as science fiction. On the therapeutic side, variceal band ligation was introduced as a safer alternative to sclerotherapy and considered a major advance; endoscopic ablation of Barrett's esophagus had not yet caught anyone's imagination. Since then, much progress has been made on many fronts, but some developments have truly set the stage for transformative change and will be highlighted in the sections below.

Endoscopy 2032

Multiplex Capsule Endoscopy

Statements about the demise of screening colonoscopy are now so abundant that they are beginning to remind us about what Mark Twain said about reports of his premature death. However, I believe this will indeed start happening within 5–10 years as gastroenterologists will literally and figuratively see the endoscope slipping from their grasp as capsule technology takes over virtually all intraluminal diagnostic procedures. The powerful intrinsic attributes of capsule endoscopy render this transformation inevitable; it can access the entire gut painlessly, does not require sedation, can be performed outside the medical environment, and causes minimal disruption of daily activity. Fundamental issues such as power and steering/locomotion will soon be overcome, and the coming revolution will be driven by technological advances that render targeted tissue sampling possible. In addition, the capabilities of the capsule will extend far beyond imaging and include monitoring of physiological, vascular, immune-inflammatory, metabolic, and microbial parameters in the gut lumen and wall. With computer-aided pattern recognitions and artificial intelligence, the need and extent of involvement of gastroenterologists in routine endoscopy will become moot. Indeed, it is not inconceivable that such smart capsules will be sold directly to consumers in retail outlets for indications that include not only colon cancer screening but for other diagnostic purposes. At the same time, the landscape for therapeutic endoscopy will change dramatically, and new and exciting opportunities will emerge as discussed below.

Flexible Endoscopic Surgery

Endoscopic techniques for cutting and apposition have reached the tipping point, and we will see these increasingly being applied to eliminate what are currently considered routine surgical procedures such as hernia repair, organ removal (appendix or gallbladder), fundoplication, and many others. Interestingly, even though natural orifice transluminal endoscopic surgery (NOTES) is to be credited for opening our minds

Abbreviation used in this paper: NOTES, natural orifice transluminal endoscopic surgery.

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to these possibilities,[3] I believe that the approach that will become most popular will be via a small incision in the abdominal wall. Small-caliber flexible endoscopes will be introduced into the peritoneal cavity and have the ability to snake their way to any nook and cranny. With the right accessories, a variety of therapeutic procedures will be performed with minimal disruption of healthy tissue and with great speed. It is important to emphasize that we are not talking about current forms of "mini-laparoscopy," where the endoscope is used only to visualize the tools. In this case, the endoscope will be used for both visualization and delivery of therapy in the peritoneal cavity, much as we do today inside the lumen.[4] Radical dissections and large organ resection, such as those required currently for cancers, may not be possible with this approach. However, I believe that in 20 years, the need for such surgery will be eliminated, as biologically tailored therapy will either be curative or at the very least will shrink tumor size to levels manageable by endoscopic approaches.

What will drive this development? Critically, this technology will take procedures out of the operating theater and into the endoscopic suite (or even bedside) where the majority will be performed under monitored anesthesia care or in some cases, just conscious sedation. This will have 2 consequences: drive costs down significantly in developed countries and, equally importantly, provide access to lifesaving therapy in developing countries without sophisticated surgical infrastructures. This is clearly disruptive technology at its best.

Who will adopt this technology? At the present time, this question is difficult to answer with confidence. On the one hand, surgeons have the greatest comfort level and anatomic knowledge required to work in the peritoneal cavity, but the vast majority are not facile with flexible endoscopy. On the other hand, gastroenterologists have had a long history of diagnostic laparoscopy (performed in the endoscopy suite) but ceded this at the advent of laparoscopic surgery. Of course, this question may be moot 20 years from now if gastroenterologists and surgeons blend into a new kind of specialist, and perhaps this development may finally drive them in that direction.

Endoscopic Metabolic Intervention

The recognition that gastric bypass and other forms of bariatric surgery may have profound effects on insulin resistance and diabetes, independent of weight loss, has been one of the most important clinical advances in recent years, but it is one that has still not received the kind of scientific attention it deserves. In part, this is because neither gastroenterologists nor surgeons have had a tradition of research in this area. Understanding the biological basis for this phenomenon will certainly need the discovery of new molecular targets and novel drugs within the next 20 years. Until then, however, we will see a mushrooming of endoscopic procedures that will mimic the physiological changes of bariatric surgery but will be performed in an outpatient setting at low cost and with minimal morbidity. The newly introduced sleeve barrier is an example of early technology that attempts to replicate the effects of bypass.[5] A different kind of example is shown in Figure 1, where an endoscopic procedure is used to achieve the same anatomic end point as bariatric surgery (in this case, sleeve gastrectomy). Future approaches will be even more sophisticated and target driven. Although the U.S. market for these procedures is undoubtedly attractive, the impact of this technology on global health cannot be overstated. Because of changes in lifestyle and eating habits, type 2 diabetes is now epidemic in much of Asia and has replaced infectious diseases as the biggest threat to health in these countries. Many of these patients are either not compliant with conventional measures or not responsive, rapidly progressing to insulin use and the spiraling consequences of hyperglycemia. A relatively inexpensive, nonsurgical, metabolic intervention can therefore add value to the lives of millions of people.

Figure 1. Contrast study of the stomach of a patient who underwent endoscopic reduction of the stomach. (Courtesy Apollo Endosurgery).

Third Space Endoscopy

Until very recently, the use of endoscopes was confined to either the lumen or the peritoneal space. However, there are other spaces (albeit latent ones) amenable for endoscopic intervention, the most notable of which is the submucosal space. The technique involves making a nick in the mucosa, then lifting it away from the layers beneath, and inserting the endoscope into the space in between. Once the endoscope is withdrawn, the initial mucosal entry site is closed, sealing off the space once again. The creation of this "third" space and its recognition as a novel arena for endoscopic intervention have opened up a slew of new opportunities, as exemplified by the procedure known as peroral endoscopic myotomy (POEM) for achalasia.[6,7] Modifications of this approach in other regions of the gut can be used for removal of either mucosal or intramural tumors as well as for drug delivery among other applications (Figure 2).

However, I believe the biggest impact of the "discovery" of the third space will be on disorders of motility, syndromes that