19 Training and Learning Curves in Thyroid Surgery

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19.1 Introduction

In 1885 the German psychologist Herman Ebbinghaus first conceived the idea of measuring the improvement in a repeated task over time [1]. The learning curve (LC) concept was first introduced in 1936 by Theodore P. Wright, an aeronautical engineer measuring the effect of learning on production costs in the aircraft industry [2]. The measurement of skills and workforce is easy to define in the industrial world through the analysis of costs, production times and product quality. The common feeling is based on the assumption that if an operation is repeated it takes less time to perform. Since this concept was translated to the full spectrum of medical specialties and procedures, its definition has become more complex and controversial. Moreover, with the advent of minimally invasive techniques, the LC concept has become a fundamental "dogma", with specific and potentially dramatic implications, particularly in all fields of surgery [3]. Over the years, with the ever-increasing demand for specific skills and excellent results, many studies have been performed on the learning process of individual surgical procedures, from the simplest to the most complex.

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The surgical LC advances through four stages which include (1) the beginning of training, (2) a gradual escalation where the surgeon becomes progressively competent, (3) the stage of minimal improvement, and finally (4) a plateau where experience has minimal improvements. A decreasing curve follows due to advancing age or for the approach to increasingly difficult cases [4].

19.2 Assessment of Performance and Learning in Thyroid Surgery

Thyroidectomy is one of the most common surgical procedures carried out in general and endocrine surgery units worldwide. There have been several advances in thyroid surgery since the first successful procedure by Theodor Kocher in 1872. Minimally invasive thyroidectomy has been developed over the past 20 years in order to minimize surgical morbidity and neck scarring. The evolution of endoscopic surgery satisfies the esthetic demand, recovery, and limited trauma in nearly all surgical disciplines, including the treatment of differentiated thyroid cancer [5].

Robotic thyroidectomy has been introduced to overcome the limitations of endoscopic procedures by providing a three-dimensional 10–12-fold magnified view, allowing easier identification of the parathyroid glands and the recurrent laryngeal nerve (RLN) with a safer and more precise dissection. Unlike endoscopic thyroidectomy, the robotic approach provides fine motion scaling, hand-tremor filtering, innovative instrumentation with extended freedom of motion, as well as surgical education.

These new exciting technologies are complex and require experienced thyroid surgeons and surgical teams to ensure safe implementation. In this chapter we aim to investigate the learning process through the different surgical approaches to the thyroid gland, providing an overview of the parameters used in defining surgical proficiency.

The current literature shows how assessing a clinician's performance is challenging.

The traditional learning method for thyroid surgery involves a primary phase in which the young surgeon only plays an assistant role during the operation and, above all for minimally invasive techniques, he is obliged to follow training courses in order to learn how to use the dedicated instrumentation and to watch the videos of the various procedures. Only after passing this preliminary phase, the trainee surgeon should perform the surgery independently, under tutor supervision for the initial cases. A recently introduced method is parallel learning. Thyroidectomy like any surgical procedure consists of several steps, each of which must be meticulously mastered and repeated until the operator becomes proficient. The steps of the procedure can be approached sequentially according to the temporal order of the operation or even better by following an order of difficulty. When the trainee surgeon has gained experience in each single step, these can be reproduced all together, resulting in the reproduction of the entire procedure.

Measures of learning surgical technique fall into two categories: surgical process and patient outcome. A detailed knowledge of the operative technique and anatomical details is required to achieve a low morbidity rate. A century ago, Kocher, the father of thyroid surgery, reported that, as his surgical experience increased from 100 to 5000 thyroidectomies, his patients' mortality rate decreased from 12.8% to 0.5% [6].

The relationship between surgeon experience and technical competence is controversial and a number of different methods for objective assessment of surgical skills have been developed [7, 8]. Furthermore, new techniques such as minimally invasive surgery require new skills with different LCs [9]. In this regard, it is important to highlight how the LC of conventional thyroidectomy is poorly investigated in the current literature. Based on our knowledge, only our previous study provides an initial estimate of the procedures necessary to complete the learning process in conventional thyroidectomy [10]. Conversely, the steps to achieve proficiency in endoscopic and robotic procedures, even if more recently introduced, are widely studied.

According to the most recent literature, the median number of operations required to achieve competence was established to be 37 procedures for a single surgeon for robotic thyroidectomy, 31 operations for minimally invasive video-assisted thyroidectomy (MIVAT), 30 procedures for endoscopic thyroidectomy through an extracervical approach, and 25–30 procedures for conventional thyroidectomy.

However, there are several confounding factors that can generate a bias in defining the learning process for thyroidectomy. These factors are essentially related to (1) the analysis criteria of the single studies, (2) the surgeon, (3) the procedure.

19.3 Analysis Criteria

What criterion is used to consider a surgeon more or less expert in a given procedure?

This concept has not been universally defined. Almost all studies use operative time to assess the LC. However, although operative time may be easily measured and compared, it is not necessarily the most appropriate marker of surgical proficiency [11]. Indeed, many studies considered other variables besides surgical time that seem to be equally or more important for patient care (Fig. 19.1): complication rate, blood loss, conversion rate, length of hospital stay, number of lymph nodes removed, tumor size, degree of complete resection, cosmetic results, intraoperative identification of the RLN and parathyroid glands, postoperative drainage volume, and postoperative pain. Only the study proposed by Ranvier et al. [12] used complication rate and severity without considering surgical time to determine the LC for transoral endoscopic thyroidectomy vestibular approach (TOETVA).

The concept of surgical time becomes even more ambiguous when applied to robotic surgery. In this field it may be subdivided into specific components such as initial robotic system setup, trocar insertion, docking, and console time, according to the steps of procedures [10, 12]. There is a lack of universal agreement on which operative time component is the most relevant for the learning process [13].

Another important variable is the size of the case series. Indeed, in the larger series the minimum number of cases to be performed for single surgeons is

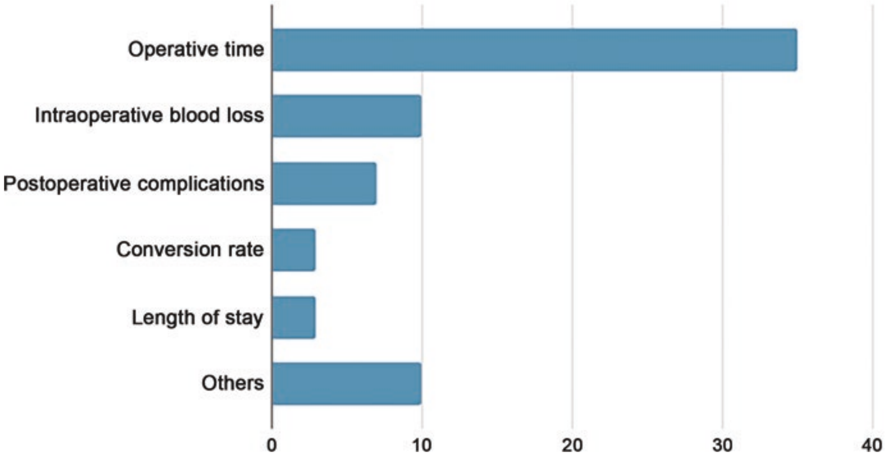

Fig. 19.1 Summary of the main evaluation items (definition and frequency) used in all studies that analyzed the learning curve for thyroid surgery

generally higher than in smaller series and above all it is possible to identify two peaks corresponding to an early and a late LC.

Finally, a large heterogeneity also derives from the statistical methodologies used in the various analyses. The cumulative sum (CUSUM) technique was adopted by the medical profession in the 1970s to analyze the LC for surgical procedures [14]. CUSUM is the running total of differences between the individual data points and the mean of all data points. It makes possible rapid and powerful assessments of changes in means, or in the slopes of trends, in data collected at regular intervals of time [14, 15]. Thus, CUSUM can be performed recursively and enables investigators to visualize the data for trends not discernable with other approaches [16].

19.4 Role of Surgeon's Experience

In many studies the LC for thyroidectomy is based on the experience of a single surgeon. Individual learning processes may differ from that of surgeons with different training backgrounds in other institutes. Other important variables that overlap with this are background and familiarity with a particular procedure and this is evident among minimally invasive techniques. Endoscopic/robotic thyroidectomy is usually approached when the surgeon has already gained anatomical and technical skills in other procedures. Conversely, open thyroidectomy represents the first step of surgical teaching and the learning process starts already during the training period involving several young trainees. Only in a few studies was the LC assessed for residents or surgeons who had just completed the training program. In most cases they were experienced surgeons. Endoscopic surgery requires the acquisition of new anatomical perspectives and hand-to-eye coordination and lacks both tactile feedback and 3D vision. The shift from an open to minimally invasive approach represents a completely new experience for surgeons and this might take a longer LC for endoscopic thyroidectomy. A surgeon who begins robotic surgery generally has already passed all these steps and, moreover, draws many advantages from the robotic system, including the precision and accuracy of anatomical dissection with 3D vision, wristed instrumentation with seven degrees of freedom of motion, lack of tremor, and comfortable seated position.

19.5 Role of Procedures

The LC for minimally invasive thyroidectomy might differ depending on the approach. The alternative approaches to the thyroid gland can be divided into cervical minimally invasive, extracervical endoscopic (robot-assisted) and transoral operations (natural orifice transluminal endoscopic surgery, NOTES). Indeed, according to the use of carbon dioxide (CO_2) gas insufflation and the site of incision, various remote-access thyroidectomy methods via axillary, breast, anterior chest, postauricular, and transoral routes have been developed to avoid neck scarring. MIVAT through a minimal-access cervical incision was first introduced by Miccoli et al. and is characterized by a single incision of 1.5–2 cm above the sternal notch [17, 18]. Transoral endoscopic thyroidectomy (TOET) is the only technique that enables thyroid surgery while completely avoiding a cutaneous incision, with better cosmetic results. The other techniques still need cutaneous incisions with substantial dissection through planes that are less familiar to the thyroid surgeon and require staged procedures or bilateral incisions to complete a total thyroidectomy [19]. Although various techniques for TOET are described, the most commonly used is the vestibular approach (TOETVA), first reported by Richmond and colleagues, due to its surgical outcomes and low complication rate [20, 21]. TOETVA and MIVAT allow for optimal bilateral visualization of anterior neck structures through familiar subplatysmal planes, and a two-sided procedure can be safely performed. The four common robotic approaches are the gasless transaxillary approach, the bilateral axillo-breast approach (BABA), the gasless postauricular facelift approach, and the transoral approach [22].

When we analyze the LC related to these procedures, we have to consider some technical aspects. First, the midline method is easier due to a similar operative view to conventional open thyroidectomy [23]. In contrast, the lateral approaches, such as transaxillary or retroauricular, might require additional time and more operations for the surgeon to familiarize with the anatomy and procedure, especially during contralateral side dissection in cases of total thyroidectomy [24]. For this reason, it would be appropriate to distinguish between hemi- and total thyroidectomies since there is a very different difficulty level between these procedures when minimally invasive techniques with lateral approach are performed. Moreover, endoscopic and robotic surgeries have a higher complication rate during the learning process [19] and above all they add unusual types of complications not seen with conventional thyroidectomy, such as lower lip hypoesthesia and weakness due to mental nerve injury and dissection of the chin area in the transoral approach, numbness of the chest wall, CO_2 embolism, perforation of the neck, chyle leakage, Horner's syndrome, and burn and trauma of the skin flap. Esthetic results become a relatively new quality criterion, not evaluated in the conventional approach.

19.6 Conclusions

The current literature lacks an objective and universal definition of the LC concept considering both surgical process and patient care. The heterogeneity of the analysis methodologies and the quality criteria evaluated, the various surgical techniques and training background of the individual surgeons are all factors that make it impossible to draw univocal results. This is even more evident when applied to thyroid gland surgery, one of the most commonly performed procedures worldwide, which has evolved in recent years with alternative approaches responding to new needs, new quality standards, and new technologies. Indications and complexities change according to the technique adopted and consequently the proficiency level required is different. Future studies should consider confounding factors and establish parameters that should be consensually recognized in the assessment of surgical performance and skills.

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