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# Anatomy and embryology of the parathyroid gland



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## KEYWORDS

Parathyroid glands anatomy;  
 Recurrent laryngeal nerve;  
 failed surgical explorations;  
 Parathyroid gland embryology;  
 ectopic locations;  
 supernumerary glands

Experienced parathyroid surgeons recognize that the embryology of the parathyroid glands would guide them in their anatomic dissections to localize the abnormal glands. This becomes particularly important in circumstances when the glands are not in their “normal” locations. Surgeons must be familiar with the embryology that is so inherently linked with the final anatomic location of the glands. It is not uncommon for patients to have undergone failed surgical explorations secondary to parathyroid glands being in ectopic locations that were not appreciated. Parathyroid embryology knowledge can bridge that gap and direct the surgeon to those sites. In this article, variations in anatomic location, relation to critical structures including the recurrent laryngeal nerve, the number of glands, and even gland size and morphology would be explored and thereby provide the platform for parathyroid surgery.

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## Introduction

A comprehensive understanding of the embryology of the parathyroid glands is requisite to the successful surgical management of parathyroid disease conditions. Although a sound knowledge of embryology is important in all aspects of head and neck surgery, an argument may be made that there is no area in the head and neck where this is as critical as in the surgical management of hyperparathyroidism. Experienced parathyroid surgeons recognize that the embryology of the parathyroid glands would guide them during surgical dissections to localize the abnormal glands. This is readily evident when the glands are not in their “normal” locations. Surgeons must be well acquainted with the embryology since it is integrally linked with the final

anatomic location of the glands. Not appreciating the parathyroid glands that are located in the ectopic locations is often the reason behind failed surgical explorations. A thorough knowledge of parathyroid embryology can aid the surgeons by directing them to the possible ectopic sites. We endeavor to explore the variations in anatomic location, relation to critical structures including the recurrent laryngeal nerve (RLN), the number of glands, and even gland size and morphology to provide the platform for parathyroid surgery. This information is invaluable not just during surgery but even in the presurgical evaluation phase when localization studies are performed to guide a directed exploration or a more extensive 4-gland exploration.

## General considerations

Parathyroid glands, first discovered by Sandstrom,<sup>1</sup> arise from the endoderm epithelial cells of the pharyngeal pouches in weeks 5–6 of gestation. In the seventh week of

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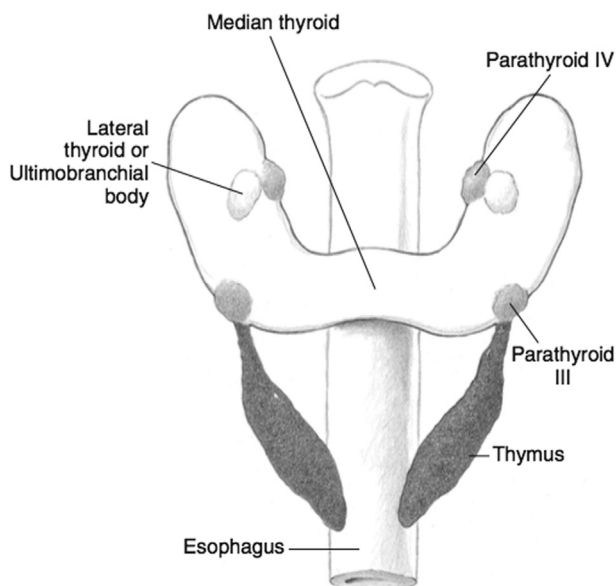
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gestation, they begin to migrate with the thyroid and thymus, both caudally and medially to their final position in the lower neck. Provided that a normal migration takes place, the inferior glands would pass beyond the superior glands and occupy a position on the dorsal surface of the lower pole of the thyroid gland or slightly more caudal in the thyrothymic ligament or the thymus (Figure 1).<sup>2</sup> The parathyroid glands have been described as flat-bean or leaf-like shaped, yellow-tan, caramel, or mahogany in color and thus may be distinguished from the brighter, less distinct yellow fat with which the parathyroids are typically closely associated. They are ovoid glands weighing roughly 35-40 mg and measuring 3-8 mm in all dimensions. They can be observed as discrete bodies gliding within the more amorphous fat surrounding them as this fat is gently manipulated.<sup>3</sup> They are composed of chief and oxyphilic cells but also consist of adipose tissue and fibrovascular stroma.<sup>4</sup>

Mirror-image symmetry usually occurs for the upper parathyroids as well as for the lower parathyroids. Finding a left gland can then assist in finding the corresponding right gland.<sup>3</sup> This symmetry has been detailed in an anatomic series that has reported 80% symmetry when comparing right and left superior parathyroid glands and 70% for the inferior glands.<sup>5</sup> The glands are primarily subserved by the inferior thyroid artery, which is the primary vascular supply to both upper and lower parathyroid glands in 76%-86% of cases.<sup>6</sup> Most parathyroid anatomic descriptions are based on surgical data. This can lead to limitations in the literature including anatomic descriptions based on the disease process, limited site exposure and search efforts as well as the natural prioritization of surgical objectives over data collection.<sup>7</sup>



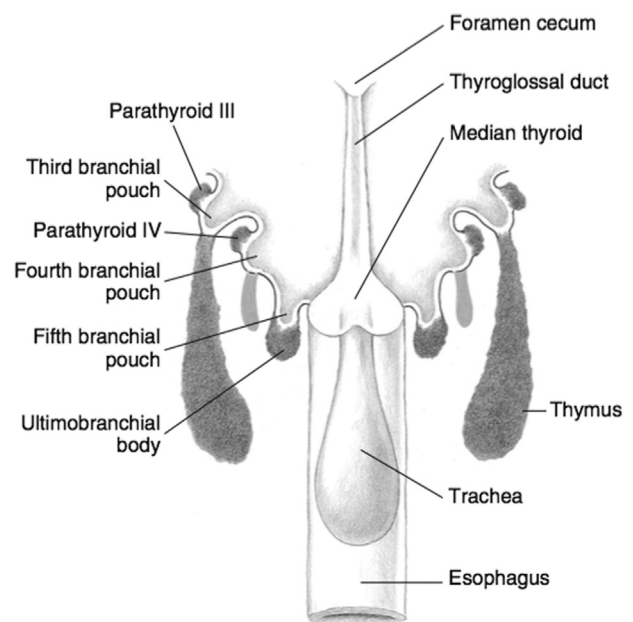
**Figure 1** A schematic representation depicting the locations of the thyroid, lateral thyroid, thymus, and parathyroid glands. During embryological development, the parathyroid III and the parathyroid IV migrate together with the thymus and ultimobranchial bodies, respectively. (Reprinted with permission from Randolph G. Surgery of the thyroid and parathyroid glands. Philadelphia: WB Saunders, 2012.)

Most commonly there are 4 parathyroid glands. However, there can be 5 or more glands present, or in rare circumstances less than 4 glands. Large autopsy series have provided insight into the numeric variation of the glands. A 13% incidence of supernumerary glands has been described. The supernumerary parathyroid glands by majority were quite small, less than 5 mg, and were located in close proximity to normal glands. In that same series, 4 glands were seen in 84% of patients and 3% of the patients had only 3 glands.<sup>5</sup> In another large series consisting of over 400 patients, 0.5% had 6 glands, 25% had 5 glands, 87% had 4 glands and 6.1% of the patients had 3 glands.<sup>6</sup> This numeric variation must be considered by surgeons performing parathyroid explorations. The supernumerary glands are also often located in the thymus and in the mediastinum.<sup>7</sup>

## Superior parathyroid glands

The superior parathyroid glands originate from the fourth branchial pouch and are associated with the lateral thyroid anlage or C-cell complex (Figure 2). Because of this origin, they are also referred to as parathyroid IV (PIV). They have further been indicated as thyroid parathyroids because of their common origin with the lateral thyroid.<sup>8</sup> As they lose their attachment with the pharyngeal wall, they attach to the posterior surface of the caudally migrating thyroid gland. As such, the superior parathyroid glands track closely with the posterolateral aspect of the respective thyroid lobes.<sup>3,9</sup> The final adult position of the superior parathyroid is less variable than that of the inferior parathyroid because of its shorter embryologic migratory path. The area of dispersal of the superior parathyroid gland is demonstrated in Figure 3.

The superior parathyroid gland is typically located at the level of the cricothyroid articulation of the larynx,



**Figure 2** Schematic representation of the primitive pharynx of an 8- to 10-mm embryo. (Reprinted with permission from Randolph G. Surgery of the thyroid and parathyroid glands. Philadelphia: WB Saunders, 2012.)

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