Anesthetic Management of Laparoscopic Adrenalectomy in Pheochromocytoma patients

Essay

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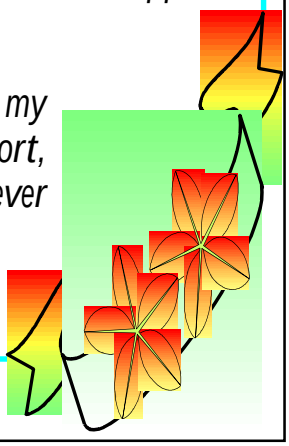

Abstract

Pheochromocytoma is a catecholamine secreting tumour that arises from the chromaffin cells of the sympathetic nervous system in the adrenal medulla and the sympathetic chain; however, it may arise anywhere in the body. Patients present with a variety of symptoms which reflect excessive secretion of catecholamines (norepinephrine, epinephrine, or dopamine) into the circulation. The released catecholamines cause significant hypertension, often severe and refractory to conventional treatment. The greatest frequency occurs in the fourth and fifth decade of life, with a slightly higher female preponderance. About 90% of pheochromocytomas occur sporadically and are benign. Around 10% of cases occur in children or adolescents.

Key word

Laparoscopic Adrenalectomy

Pheochromocytoma

Anesthesiology

Contents

List of Figures

List of Figures (Cont.)

List of Abbreviations

^{18}FDA	18-fluorodopamine
^{18}F-DOPA	18-fluoro-dihydroxyphenylalanine
^{18}F-FDG PET-CT	18-fluorodeoxyglucose
ACTH	Adrenocorticotropic hormone
BMI	Body mass index
CT	Computed tomography
ECG	Electrocardiography
IAP	Intra-abdominal pressure
ISP	International Symposium on Pheochromocytoma
LA	Laparoscopic adrenalectomy
LC-ED	Liquid chromatography with electrochemical detection
LCMS/ MS	Liquid chromatography with tandem mass spectrometry
MAO-A	Monoamine oxidase A
MEN	Multiple endocrine neoplasia
MIBG	Meta-iodobenzyl guanidine
MIBG	^{123}I-meta-iodo-benzyl-guanidine
MRI	Magnetic resonance imaging
MSCT	Multislice spiral computed tomography
PACU	Post-anesthesia care unit
PASS	Pheochromocytoma of the Adrenal Gland Scaled Score
PET-CT	Positron emission tomography
PPGLs	Pheochromocytoma and extra-adrenal paraganglioma

PRA	Posterior retroperitoneoscopic adrenalectomy
SDH	Succinate dehydrogenase
SUV	Standardized uptake value
VMA	Vanillylmandelic acid
VMAT1	Vesicular monoamine transporter 1
VMAT2	Vesicular monoamine transporter 2

Introduction

Adrenal glands are situated in the extraperitoneal perirenal space. There are great varieties of the adrenal diseases and their clinical manifestations are complicated. [1] Therefore, adrenal glands are one of the interesting investigative subjects of the clinic, especially in medical imaging and surgery.The development of multislice spiral computed tomography (MSCT) and its image postprocessing ability as well as modern high-speed scanning sequence of MRI provide useful images that more clearly demonstrate the complicated anatomical relationships of the adrenal glands and their diseases on the transverse, sagittal, coronal, and oblique planes. [2]

The laboratory workup of patients with pheochromocytoma and extra-adrenal paraganglioma (PPGLs) has traditionally focused on biochemical measurements of tumor secretory products or their metabolites, with ultimate diagnosis resting on routine histopathology and immunohistochemistry. While such testing remains important, the needs to distinguish potentially metastatic from benign tumors and to identify tumors with a hereditary basis have stimulated searches for additional means to stratify patients according to risk of metastasis or presence of a particular mutation. Biomarkers based on traditional biochemical tests, such as profiles of catecholamine metabolites and graninderived peptides, provide utility for both purposes, while novel biomarkers are being identified by proteomic and transcriptomic studies, the latter including microRNA expression profiling. Histopathological scoring methods for predicting metastatic potential, such as the Pheochromocytoma of the Adrenal Gland Scaled Score (PASS), are limited by poor interobserver concordance, discrepant results between studies and incomplete knowledge of how scores relate to genotype. [3]

Immunohistochemical staining for succinate dehydrogenase (SDH) subunit B to triage patients for genetic testing of SDH subunit genes illustrates the growing importance of pathology as an adjunct to genetic testing for disease stratification. Although considerable effort has been expended on microarray-based platforms to identify biomarkers of malignancy, as yet, none of those proposed have been demonstrated to reliably discriminate malignant from benign disease any better than the PASS. Because of the heterogeneity of PPGLs and variable time between first appearance of tumors and identification of metastases, any prospective study to establish prognostic efficacy requires large numbers of patients and extended follow-up. [3]

Pheochromocytoma is a rare tumor arising from chromaffin cells in adrenal medulla or other paraganglia in the body, which may be associated with many genetic syndromes and mutation. The role of endocrinologist is in biochemical diagnosis of suspected cases; its anatomic and functional localization with the help of imaging like CT, MRI, and nuclear scanning; preoperative control of hypertension; and postoperative follow-up of cases that have undergone surgical resection. Familial and genetic screening of cases and their family is important to detect occult cases. Endocrinologist will also play a role in cases with malignant pheochromocytoma in assessment of metastasis, control, chemoradiotherapy, and follow-up. [4]

Pheochromocytoma has got multidimensional challenging aspects in spite of our improved understanding of its physiological and clinical behavior during surgical resection. This neuroendocrine tumor is associated with a most unpredictable and fluctuating clinical course during anesthesia and surgical intervention. The clinical difficulties and challenges increase manifold in

patients with undiagnosed or accidental diagnosis of pheochromocytoma who present to the hospital for the treatment of some other disease or emergency. The most common manifestations of this clinical spectrum include hypertension, headache, palpitations and episodic sweating. The definite and only treatment for this rare tumor is surgical resection which itself is very challenging for an anesthesiologist. This essay reviews the pre-operative evaluation, pharmacological preparation, intraoperative and post-operative management of patients with pheochromocytoma especially from anesthesiologist's perspectives. [5]

Today, laparoscopic technique is preferred for many types of surgical procedures. Advantages of laparoscopic surgery include small incisions, postoperative pain reduction, decreased analgesic consumption, small scar formation, decreased incidence of postoperative pulmonary morbidity and ileus, rapid recovery, shorter hospital stay, higher patient satisfaction, and cost-effectiveness. [6, 7]

The hemodynamic changes during laparoscopy vary with preexisting cardiopulmonary comorbidities, anesthesia and surgical technique, intra-abdominal pressure (IAP), carbon dioxide absorption, the patient’s intravascular volume, ventilation technique, positioning, and time of surgery. Particularly in higher than 12mmHg IAP, significant changes are seen, and the risk of the physiological changes may decrease by reducing the pressures.in laproscopic surgery pH drops and carbon dioxide values increase. [8]

Laparoscopic adrenalectomy became increasingly popular in recent years.[9]Most laparoscopic adrenalectomies are performed owing to endocrine causes such as primary hyperaldosteronism, Cushing syndrome, and pheochromocytoma. Other indications of laparoscopic adrenalectomy are

adrenal cysts, metastases, primary malignant tumors of adrenal gland, adrenal hemorrhage, and tuberculosis. [9]

The anesthetic management of these laparoscopic adrenalectomies can be very challenging: in addition to commonly observed changes in heart rate and blood pressure during insufflation and desufflation applied in laparoscopic surgery, the adrenal gland hormones are secreted by manipulation of the adrenal gland during surgical manipulation and might cause severe changes on hemodynamics. [10]

Anatomy of Adrenal Gland

THE ADRENAL GLAND is composed of two separate functional units, the cortex and the medulla. Although these units have completely separate origins, they unite within a single capsule during fetal life. (11)

The Cortex

The cortical primordium of the adrenal gland arises from developing peritoneal epithelium or coelomic mesoderm. These mesenchymal cells are located on the posterior trunk at the angle of the genital ridge and the root of the mesentery. This group of cells grows rapidly and penetrates the retroperitoneal mesenchyme near the cranial end of the mesonephros to form the primitive cortex by the fifth week of embryologic development. This primitive cortex (provisional cortex, fetal zone, transitional zone, X-zone) accounts for the bulk of the cortex during fetal life. At 7 weeks (12 mm embryo), a second wave of cells migrate from the cortical primordium to envelope the primitive cortex and form a permanent cortex. At the end of the 8th week, the cortical mass separates from the peritoneal mesothelium and becomes encapsulated by connective tissue. The gland is now much larger than the kidney. (12)

The primitive cortex atrophies immediately after birth. This change appears to be related to the birth process because it occurs at the same rate in premature and term infants. This process is seen as vascular engorgement, so marked as to resemble hemorrhage. As a result of this atrophy, the adrenal glands lose third of their weight by the 2nd week after birth. The primitive cortex is completely resorbed by the end of the 1st year. The outer or permanent cortex begins to differentiate after birth. By the 3rd year, differentiation into zona glomerulosa, fasciculata, and reticularis is complete. (12)

The Medulla

Ectodermal cells from the neural crest migrate forward to become the primitive sympathetic ganglia. Some of these cells do not differentiate into neurons but instead become endocrine cells. They are called chromaffin cells or pheochromoblasts because they stain brown when exposed to chromic acid salts. This reaction is due to the presence of epinephrine and norepinephrine in the cells. These cells are widely dispersed in the embryo. At about the 10^{th} week of development, a group of chromaffin cells from the primitive sympathetic ganglia migrate and invade the medial aspect of the fetal adrenal cortex. By the 18^{th} week, these cells have achieved their position central to the cortex. During fetal development, most medullary functions originate from the larger paraganglionic masses. Significant adrenal medullary function is not evident until about the 11^{th} week of development. After birth, much of the paraganglionic tissue atrophies and the adrenal medulla predominate. Some of the paraganglionic chromaffin tissue may remain as discrete structures near the origin of the celiac and of the superior mesenteric artery. Accessory medullary tissue may also be found with sympathetic nerves as well as near the origin of the inferior mesenteric artery, where it is called the organ of Zuckerkandl. (12)

It is of interest that during gestation and at birth the catecholamine content of the medulla and paraganglionic tissue is almost all norepinephrine. By 2 years of age this changes, so that 80% of the medullary output is epinephrine. (13)

Anatomy

The adrenal gland may be described as having superior, middle, and basal portions, or tail, body, and head. The head is the most inferior portion and contains most of the medulla, with a corticomedullary ratio of 4:1. The body has a small amount of medulla, resulting in a corticomedullary ratio of 15:1. The tail is essentially all cortex. Microscopic remnants may also be found in the course of the sympathetic chain. (11)

Anatomic Relationships

The adrenal glands are located at the level of the 11^{th} or 12^{th} rib lateral to the vertebrae in the extreme supero-posterior portion of the retroperitoneal perirenal space. (14)

The left gland extends as low as L-l, often joining the anterior portion of the renal vascular pedicle where the adrenal vein drains into the renal vein. The glands are attached to the inner surface of the anteromedial and superior aspects of the perirenal fascia. Like the kidney, the glands are surrounded by fatty areolar tissue, which is useful in separating them from adjacent structures such as the kidneys, aorta, and liver (Fig 1). (14)

On the right, this areolar tissue thins and practically disappears between the gland and the posterior aspect of the inferior vena cava. It is important to recognize that the kidney is not fixed to the perirenal fascia. For this reason, deep inspiration or the upright position often causes discernible separation of the adrenal and kidney. This separation maneuver, particularly during sonography, can be employed to help demonstrate whether a mass is of renal or adrenal origin. (14)