ANAESTHETIC MANAGEMENT OF PATIENTS WITH PHAEOCHROMOCYTOMA

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The presence of a phaeochromocytoma is a hazardous and dramatic cause of arterial hypertension accounting for approximately fewer than 0.1% of all cases of hypertension (Manger and Gifford, 1977).

Phaeochromocytomas are functionally active, catecholamine-containing tumours of chromaffin tissue, found usually in the adrenal medulla, but they may occur at any site where chromaffin tissue is located. Although the frequency of phaeochromocytoma is low, its diagnosis is important. Whereas the hypertension is usually cured by surgical removal of the tumour, undetected phaeochromocytoma is usually fatal. Although anaesthesia in patients with unsuspected phaeochromocytoma is associated with a high mortality rate, recent reports describing anaesthetic management of patients for elective removal of phaeochromocytoma have shown that perioperative mortality may be almost completely eliminated (Remine et al., 1974; Desmonts et al., 1977; Roizen et al., 1982). This reduction in operative mortality is the result of our increased knowledge of the pathophysiology of the tumours.

This review summarizes the data from the literature regarding the diagnosis of phaeochromocytoma and the anaesthetic management of patients with these tumours.

Physiological considerations

Phaeochromocytomas are tumours of neuroectodermal origin which arises in chromaffin tissue of the sympathoadrenal system. Chromaffin cells occur in association with the coeliac, mesenteric, renal, adrenal, hypogastric, testicular and paravertebral sympathetic nerve plexuses. The major sites of phaeochromocytoma are the adrenal medulla (90%), the paraganglia cells of the sympathetic nervous system and the organ of Zuckerkandl. Phaeochromocytoma may be also found in the chest and neck. Multiple and extra-adrenal tumours are far more common in children (35%) than in adults (8%) (Manger and Gifford, 1977).

Most phaeochromocytomas secrete a combination of noradrenaline and adrenaline, but the former is usually the predominant amine. Rarely, a tumour may secrete adrenaline alone. The signs and symptoms of phaeochromocytomas result from the release of these highly potent amines. The half-life of these compounds is less than 1 min and this rapid removal results from rapid enzymatic degradation by mono-amine-oxidase and catechol-methyltransferase and also from the neuronal re-uptake process. The urinary metabolites of catecholamines are total metanephrines, that is metanephrine plus normetanephrine and vanillyl-mandelic acid (VMA). The amount of free catecholamine excreted in urine is very small. Various chemical tests used for demonstrating increased excretion of catecholamine, metanephrine, normetanephrine and VMA have proved invaluable in diagnosing patients with phaeochromocytoma.

Clinical presentation

Age and sex

Phaeochromocytoma may occur at any age, but the greatest frequency is seen in the fourth and fifth decades; 10% of these tumours are found in children. In adults, the sex distribution of the patients shows a slight higher female preponderance (55–60%). In children the sex ratio is different, since approximately 70% of phaeochromocytomas occur in boys (Manger and Gifford, 1977).

Symptoms and signs

The great variety of clinical manifestations encountered in patients with phaeochromocytoma has been emphasized. Headache, excessive sweating and palpitations are the three most commonly experienced symptoms. Often, symptoms arise in an explosive manner. Attacks last less than 15 min in approximately 50% and less than 1 h in 80% of patients. Symptoms may be provoked by various factors: postural changes, exercise, anxiety, trauma, pain, administration of certain drugs.

Hypertension is present in more than 90% of adult patients (De Oreo et al., 1974; Remine et al., 1974; Desmonts et al., 1977). In our clinical experience, the characteristic paroxysmal hypertension with normal arterial pressure between crises is present in only 30% of patients. In the remainder, hypertensive crises are superimposed on permanent hypertension. Orthostatic hypotension, in a hypertensive patient not being treated with antihypertensive agents, suggests phaeochromocytoma. It may occur in 70% of patients with these tumours. Alterations in heart rate are often observed during hypertensive attacks. Various types of arrhythmia may occur: sinus tachycardia, nodal rhythms, multiple ectopic ventricular beats, ventricular tachycardia.

Retinopathy of stage 3 or 4 is found in 50% of patients with phaeochromocytoma associated with sustained hypertension. In contrast, 50% of patients with paroxysmal hypertension have a normal retina on examination (Manger and Gifford, 1977).

Myocardial alteration may result from persistently increased concentrations of circulating catecholamines. Cardiomyopathy with congestive heart failure may be the main clinical feature (Baker et al., 1972; Garcia and Jennings, 1972).

Atypical manifestations may be observed when phaeochromocytoma occurs in childhood or during pregnancy (Manger and Gifford, 1977). The pregnancy complicated by phaeochromocytoma may be confused with toxæmia and pre-eclampsia.

Hypermetabolic states produced by the catecholamines may be mistaken for thyrotoxicosis or anxiety states. In a small percentage of patients with phaeochromocytoma there may be no signs or symptoms and the tumour may be found accidentally at operation or postmortem (Manger and Gifford, 1977).

Associated diseases

Some disease entities and familial syndromes may be associated with phaeochromocytoma. Familial phaeochromocytoma may be associated with the multiple endocrine neoplasm (MEN). MEN type II(a) comprise an association of medullary thyroid carcinoma or parathyroid adenoma, or both, with phaeochromocytoma. MEN type II(b) consist of medullary thyroid carcinoma, mucosal neuromas and marfanoid habitus with phaeochromocytoma. Neurofibromatosis (Von Recklinghausen’s disease) occurs in approximately 5% of patients with phaeochromocytoma. Conversely, the frequency of phaeochromocytoma in neurofibromatosis may be less than 1% (Brasfield and Das Gupta, 1972). Choledolithiasis is also observed frequently in patients with phaeochromocytoma—32 of 138 patients seen at the Mayo Clinic exhibited this association (Remine et al., 1974).

Diagnosis

The presence of phaeochromocytoma is suspected on the basis of clinical manifestations and diagnosis is confirmed biochemically with the demonstration of increased catecholamines and their metabolites in urine and of increased plasma catecholamine concentrations. Measurement of total metanephrine in a 24-h urine specimen is favoured for screening, since it has been reported as the most reliable method of detecting phaeochromocytoma (Remine et al., 1974). The excretion of VMA in urine is also frequently measured. However, the results of urinary determinations of these indices of catecholamine production may be erratic (Bravo et al., 1979).

A comparison of three biochemical tests (plasma catecholamines, VMA and metanephrines) has demonstrated the value of plasma catecholamines in the diagnosis of phaeochromocytoma and its greater accuracy than measurement of urinary catecholamine metabolites (Bravo et al., 1979).

With the advent of highly sensitive biochemical methods for detecting excessive catecholamine production, pharmacological tests are now seldom performed for diagnosis. However, confirmation of diagnosis remains a problem in 5—10% of hypertensive patients with borderline increases in plasma catecholamine concentrations. Provocative tests with glucagon and histamine, combined with plasma catecholamine determination, have been reported to be reliable and safe if performed correctly (Manger and Gifford, 1977). More recently, a safe and simple suppression test with clonidine has been described (Bravo et al., 1981). A single oral dose of clonidine 0.3mg has no effect on plasma noradrenaline concentration in patients with phaeochromocytoma. In contrast, plasma noradrenaline concentration was decreased markedly in hypertensive patients without phaeochromocytoma. Both groups had similar reductions in arterial pressure.

Localization

Tumour localization is an essential part of surgical management. Intravenous pyelography has often failed to demonstrate the phaeochromocytoma: it was positive in only 36% of patients with proved
phaeochromocytoma (Stewart et al., 1978). Ultrasonography is a valuable non-invasive technique for locating abdominal tumours and detects phaeochromocytoma in 85% of cases (Chatel et al., 1979). Angiography (aortography, selective angiography and adrenal phlebography) is a very valuable radiographic technique for locating a tumour. Selective arteriography can define accurately the location and extent of the tumour in 90% of patients with proved phaeochromocytoma. However, it is an invasive technique with serious potential complications including hypertensive crises, severe arrhythmias and pulmonary oedema (Rouby et al., 1980).

Computerized axial tomography has proved a valuable diagnostic aid to detect the presence of phaeochromocytoma; it is as accurate as selective angiography and carries less risk (Stewart et al., 1978). It is now suggested that patients with phaeochromocytoma suspected from biochemical tests be examined first with computed tomography. The accuracy of this procedure is sufficient to permit surgery without the patient undergoing potentially hazardous angiographic studies. When the tumour is less than 3 cm in size, it may be missed on scan (Stewart et al., 1978). In these cases, scintigraphic localization has been proposed using radiocholesterol (Kehlet et al., 1976) or, more recently, metaiodo-benzyl-guanidine (Sisson et al., 1981).

Because there is a high frequency of complications related to phaeochromocytoma, treatment must be surgical following a period of stabilization with medical therapy. In pregnancy, the operation may be delayed. When the diagnosis is made during the third trimester, combined Caesarean section and removal of phaeochromocytoma has been recommended (Galletly, Yee and Maling, 1983). Management during the first and second trimester is not well defined, but it may comprise termination of pregnancy, removal of the tumour or medical management until delivery, according to evaluation of each individual patient.

Preoperative preparation

Although no controlled randomized clinical study has been performed on the value of preoperative preparation with adrenergic blocking agents, this is generally regarded as the major factor in the reduction of perioperative morbidity. The alpha-adrenergic blocking agent used commonly for preoperative preparation is phenoxybenzamine, which possesses a long duration of action—a half-life exceeding 24 h. Because some patients are sensitive to the effects of this agent, it should be started in the adult in doses of 20 mg/day by mouth, combined with monitoring of arterial pressure in the supine and standing positions. The dose is increased by 10-mg increments daily until reduction in symptoms and stabilization of arterial pressure have been achieved. Most patients require a dose of 60–250 mg/day and the optimal duration of preoperative therapy is approximately 10–14 days.

According to Roizen and colleagues (1983), the following criteria are recommended as signs of adequate treatment: (1) arterial pressure not greater than 165/90 mm Hg should be observed for 48 h before surgery; (2) orthostatic hypotension should be present but greater than 80/45 mm Hg; (3) the electrocardiogram should be free from changes in ST segment and T waves for at least 2 weeks; (4) no more than one premature ventricular contraction should be present every 5 min.

The advantages of using phenoxybenzamine are that wide fluctuations in arterial pressure during surgery may be reduced and re-expansion of plasma volume is facilitated by counteracting the vasoconstrictive effects of catecholamines. Some authors (De Oreo et al., 1974; Desmonts et al., 1977; Manger and Gifford, 1977) have questioned the routine use of phenoxybenzamine before operation because if blockade is complete, the surgeon may not utilize increases in arterial pressure as a guide to tumour location or recognition of the presence of additional tumours if hypertension persists after removal of the first. Comparison of intraoperative variations in arterial pressure in phenoxybenzamine-prepared and -unprepared patients described in the literature has not revealed any clear differences in the hypertensive responses (requiring phentolamine or sodium nitroprusside treatment) to palpation of the tumour.

Preoperative beta-blockade with propranolol has been used either alone or in combination with phenoxybenzamine (Ross et al., 1967). This therapy is indicated in the presence of persistent tachycardia or arrhythmias which may be aggravated by alpha-adrenergic blockade, and this may be hazardous in the presence of angina pectoris. However, propranolol should never be used in the presence of a phaeochromocytoma without concomitant alpha-adrenergic blockade, since beta-blockade may significantly increase arterial pressure. Furthermore, its efficacy in preventing intra-operative arrhythmias has been questioned (Perry and Gould, 1972). In addition, decreased left ventricular performance
can occur during tumour manipulation (Marty et al., 1982) and this may be aggravated by preoperative beta-blockade.

Recently, combined use of prazosin and propranolol has been proposed for preoperative management of phaeochromocytoma (Cubeddu et al., 1982). This combination was effective for controlling arterial pressure in three patients with noradrenaline-secreting tumours. Optimal symptomatic and arterial pressure control was achieved with prazosin 6–10 mg/day and propranolol 120–480 mg/day. The efficacy of prazosin is related to a reduction in peripheral vasculature through selective blockade of alpha-1 receptors. The selective action of prazosin prevents the occurrence or enhancement of tachycardia through non-discriminative alpha-adrenergic blockade.

In our clinical experience, prazosin has been used either alone for three patients or in combination with labetalol for one. Stabilization of arterial pressure was obtained in four cases. However, phentolamine was needed in three patients during manipulation of the tumour. However, tachycardia and arrhythmia did not occur in any patient. This effect is probably related to a specific action of prazosin on postsynaptic myocardial alpha-1 adrenergic receptors, as was recently demonstrated in dogs (Maze and Smith, 1983). In this study, the threshold for adrenaline during halothane anaesthesia was increased to a greater extent by alpha-1 blockade with prazosin than by relatively selective beta-1 blockade with L-metoprolol.

Labetalol has been used also in the preoperative management of phaeochromocytoma (Kaufman, 1979). This antihypertensive agent antagonizes both alpha- and beta-adrenergic receptors. The beta-receptor blocking effect of labetalol is qualitatively similar to that of propranolol, but its alpha-receptor blocking effect is approximately one-tenth as potent as phentolamine (Goodman and Gilman, 1980). However, labetalol used alone is not able to control arterial pressure if large quantities of noradrenaline are released from the tumour (Russell et al., 1982).

Although hypovolaemia is not present in all patients with phaeochromocytoma (Sjoerdsma et al., 1966), preoperative administration of volume-expanding fluids has been recommended with preoperative alpha-adrenergic blockade to prevent arterial hypotension following tumour removal (De Oreo et al., 1974). Preoperative fluid loading monitored with a Swan–Ganz catheter has also been suggested in order to obtain a left ventricular function curve and, consequently, diagnose altered left ventricular performance (Pinaud et al., 1982). In our clinical experience, blood volume expansion may be commenced at the beginning of anaesthesia and adjusted according to haemodynamic monitoring data before and after removal of the tumour.

**Anaesthesia**

All commonly used premedicant agents have been used successfully in the management of patients with phaeochromocytoma. Substantial preanaesthetic medication should be administered to minimize the anxiety associated with transfer to the operating theatre. Atropine is usually omitted because of induced tachycardia.

Spinal anaesthesia (Goldfien, 1963) and extradural analgesia (Cousins and Rubin, 1974; Roizen et al., 1982) have been utilized on a few occasions with satisfactory results. It should be noted that sympathetic blockade may enhance the sensitivity of receptors to circulating catecholamines released from tumours. In Roizen's series, a vasodilator was required in each patient undergoing regional anaesthesia during manipulation of the tumour (Roizen et al., 1982). Recently, two cases have been reported in which Caesarean section was performed successfully under extradural analgesia in patients whose pregnancy was complicated by phaeochromocytoma (Stonham and Wakefield, 1983).

General anaesthesia is the usual technique chosen and virtually all anaesthetic agents have been used at some time with success. Induction with thiopentone has been used commonly. A recent study has shown that a small dose of this agent induces a decrease in plasma catecholamines (Joyce, Roizen and Eger, 1983). Although ether is alleged to release catecholamines, it was considered as the anaesthetic agent of choice at the Mayo Clinic (Perry and Gould, 1972). Halothane, enflurane and isoflurane cause a dose-dependent decrease in plasma catecholamine concentrations involving both adrenaline and noradrenaline (Perry, Van Dyke and Theye, 1974; Roizen et al, 1974). Halothane has been used for its hypotensive properties (Scott et al., 1976; Desmonts et al., 1977; Roizen et al., 1982), but it sensitizes the myocardium to the effects of catecholamines by decreasing the arrhythmogenic threshold doses for adrenaline (Maze and Mason, 1983). The frequent occurrence of severe arrhythmias observed in our patients with phaeochromocytoma anaesthetized with halothane led us to replace this agent with neuroleptanalgesia.
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(Desmonts et al., 1977). More recently, enflurane and isoflurane have been used for the removal of phaeochromocytoma with good results. A low occurrence of arrhythmia has been reported during surgery with these agents (Kopriva and Eltringham, 1974; Conner, Miller and Katz, 1975; Ortiz and Diaz, 1975; Kreul, Dauchot and Anton, 1976; Roizen et al., 1982).

Neuroleptanalgesia has been used successfully by many authors (Remine et al., 1974; Desmonts et al., 1977; Roizen et al., 1982). A combination of droperidol with either fentanyl or phenoperidine is the most common combination used. Droperidol antagonizes the pressor effects of catecholamines and decreases the occurrence of arrhythmias. Experimentally, the dose of adrenaline required to trigger arrhythmia is doubled following pretreatment with droperidol (Bauer, Kreuscher and Menzel, 1971). This effect may be related to the alpha-1 blocking properties of this butyrophenone, as has been demonstrated for prazosin (Maze and Smith, 1983). However, several reports have suggested that marked hypertensive responses may follow administration of droperidol to patients with phaeochromocytoma (Yusa, Hashimoto and Shima, 1973; Sumikawa and Amakata, 1977; Bittar, 1979).

We have not observed this response, but the dose of droperidol we have used is far greater than that used when hypertensive responses have occurred. In the majority of the 15 cases that have been reported, droperidol 2.5 mg was administered with fentanyl 50 μg, although two patients received as much as 12.5 mg of droperidol (Yusa, Hashimoto and Shima, 1973). A possible explanation is that these relatively small doses of droperidol are insufficient to produce vasodilatation, but cause a brief release of catecholamines at sympathetic nerve endings (Hyatt, Muldoon and Rorie, 1980). In these patients, in whom there are excessive stores of catecholamines, a similar mechanism may lead to hypertensive responses (Oh et al., 1978). Several studies of the effects of anaesthetic doses of opioids on the sympathetic nervous system suggest that plasma concentrations of catecholamines are related to the depth of anaesthesia (Stanley et al., 1980; Roizen, Horrigan and Frazer, 1981). Plasma noradrenaline concentrations increased during surgery after fentanyl 15 μg kg⁻¹ and remained increased after 30 μg kg⁻¹, but decreased toward base line values after 50 μg kg⁻¹ (Hicks, Mowbray and Yhap, 1981). For blocking adrenergic response to surgical incision in 95% of patients, the dose for morphine sulphate was 1.45 mg kg⁻¹ (with 60% nitrous oxide). The changes in heart rate and arterial pressure correlated significantly with changes in plasma noradrenaline concentration.

Neuromuscular blocking agents used for surgery for phaeochromocytoma have included suxamethonium, tubocurarine, pancuronium and vecuronium. Gallamine should be avoided because of its anticholinergic effect and tubocurarine because of its histamine-releasing properties (Moss et al., 1981). Tachycardia and hypertension occurred in patients with phaeochromocytoma receiving pancuronium for intubation (Janeckzo et al., 1977) related probably to an increase in plasma noradrenaline (Cummings, Russell and Frewin, 1983). Suxamethonium should be avoided for tracheal intubation because of its autonomic side-effects and mechanical stimulation of the tumour by fasciculations. Cardiac arrhythmias associated with suxamethonium have been reported when the drug has been used for tracheal intubation (Etsten and Shimosato, 1965) and when used in an i.v. infusion (Stoner and Urbach, 1968). Recently, vecuronium, a new non-depolarizing muscle relaxant, was given to three patients with phaeochromocytoma, causing small increases in plasma catecholamines without change in cardiovascular variables (Gencarelli et al., 1981).

In our experience, pancuronium has been used in approximately 80 patients with phaeochromocytoma without any problems, and we believe that the type of muscle relaxant used is of secondary importance.

Intraoperative management of cardiovascular disturbances

Hypertensive crises

Virtually all patients exhibit increases in systolic arterial pressure above 200 mm Hg for some period of time irrespective of the use or not of preoperative alpha-adrenergic blockade. We have recently studied the events associated with hypertensive responses during phaeochromocytoma resection in eight patients by simultaneous determination of haemodynamic variables and of plasma catecholamine concentrations.

Increases in arterial pressure appeared to have two distinct origins. First, they were related directly to noxious stimuli which occurred during tracheal intubation, skin incision and abdominal exploration and were not accompanied consistently by increased secretion of catecholamines or by other significant
haemodynamic changes (fig. 1). An increase in arterial pressure without an increase in noradrenaline concentrations may be more apparent than real as tumour-related increases in catecholamine concentrations are so great as to render undetectable the relatively small increase in physiologically released noradrenaline. These exaggerated arterial pressure responses presumably result from release of catecholamine from the excessive stores in adrenergic nerve endings (Bravo et al., 1979). These cardiovascular manifestations of stress in response to noxious stimuli may be blocked by deepening the level of anaesthesia (Roizen, Horrigan and Frazer, 1981). Thus, depth of anaesthesia (as opposed to type of anaesthetic agent) might be the most important factor in prevention of hypertensive crises occurring before manipulation of the tumour.

The second type of hypertensive response was associated with palpation of the tumour. These were more severe than hypertension produced by noxious stimuli and, as reported by others (Feldman, Blalock and Fagrasos, 1978; Hamberger et al., 1981; Vater, Achola and Smith, 1983) were always accompanied by marked increases in plasma noradrenaline and adrenaline concentrations. Additionally, they were accompanied by a significantly increased systemic vascular resistance and pulmonary capillary wedge pressure and in, some instances, decreased cardiac index suggesting left ventricular dysfunction.

In all instances, hypertensive responses were amenable to treatment with phentolamine and those induced by palpation of the tumour responses to cessation of this manoeuvre. Treatment is necessary if the arterial systolic pressure exceeds 200 mm Hg for more than 1 min. Phentolamine has been the drug used most commonly for this purpose, because of its specificity of alpha-adrenergic blocking action. However, some authors have claimed that phentolamine has too long an onset and duration of action (Roizen, 1983) and have recommended sodium nitroprusside in preference since onset of action is immediate and recovery occurs in 1–2 min. SNP has been used with satisfactory results by several investigators (Csanky-Treels et al., 1976; Stamenkovic and Spierdijk, 1976) and by ourselves in several patients, although comparison of nitroprusside with phentolamine has not revealed any clear difference in our experience.

Intravenous nitroglycerin is less potent than sodium nitroprusside but is, nevertheless, a rapidly acting agent which affects mainly capacitance vessels. It was used successfully in the anaesthetic management of several patients undergoing resection of phaeochromocytoma (Chelly et al., 1980; McDonald et al., 1982). In a few patients, i.v. labetalol has been administered to control hypertensive responses to induction of anaesthesia and palpation of the tumour (Bailey, 1979; Kaufman, 1979).

Arrhythmia

Both lignocaine and beta-adrenergic blocking agents have been used for the treatment of arrhythmia during surgery for phaeochromocytoma. Propranolol has been used frequently with success (Ross et al., 1967), but its duration of action following i.v. administration is 30–45 min and the action may persist following removal of the tumour. Moreover, decreased myocardial function during operation may be aggravated by beta-blockade. Lignocaine consistently produced good results in our previous series of patients anaesthetized with halothane (Desmonts et al., 1977). Its short duration of action and the absence of negative inotropic properties in a dose of 1 mg kg\(^{-1}\) are the main advantages of lignocaine and we believe it is the antiarrhythmic agent of choice in this type of surgery. In our experience the use of droperidol for anaesthesia has markedly reduced the need for lignocaine since less than 10% of patients exhibited arrhythmias requiring the administration of lignocaine.
Arterial hypotension following removal of the tumour

A sudden decrease in plasma catecholamine concentrations following removal of the phaeochromocytoma may result in marked hypotension. Replacement of blood volume with careful cardiovascular monitoring is now recognized as the treatment of choice for this situation. Fluid infusion is commenced before removal of the tumour and the rate of infusion is increased following resection. In our experience, the volume of infused fluids in addition to compensation for blood loss ranged from 500 to 3000 ml (mean 1100 ± 500 ml) before resection and 1200 ± 200 ml (mean ± SD) after resection (Desmonts et al., 1977). If vasopressors are required, noradrenaline, phenylephrine and dopamine have all been recommended.

After operation, approximately 50% of patients remain hypertensive for a few days. This is not surprising, as it has been reported that catecholamine concentrations remain above normal for up to 1 week following phaeochromocytoma resection, probably because of excessive stores of catecholamines in adrenergic nerve endings (Bravo et al., 1979). Approximately 30% of patients remain definitively hypertensive (Remine et al., 1974). The course of the patients after operation is usually uneventful, at least in those with a single tumour. Complications following surgery can occur in patients with malignant phaeochromocytoma when all the chromaffin tissue cannot be removed or when there is extensive organ involvement from long-standing hypertension (Gould and Perry, 1972; Scott et al., 1982). Hypotension and low urinary output may indicate a blood volume deficit requiring fluid infusion.

Monitoring

Monitoring during anaesthesia includes continuous measurement of arterial pressure using a radial arterial cannula, urine production by catheterization of the bladder and continuous ECG monitoring. Measurement of pulmonary capillary wedge pressure and cardiac output during phaeochromocytoma resection may be useful (Mihm, 1982). Patients with phaeochromocytoma may exhibit a discrepancy between right- and left-sided filling pressures, particularly during manipulation of the tumour or during rapid infusion of fluid. These findings were observed not only in patients with previous congestive heart failure, but also in patients without any apparent cardiac dysfunction before operation (Mihm, 1982). Myocardial damage related to chronic increase in catecholamines may cause an alteration in left ventricular performance. In our experience, some patients have demonstrated episodes of impaired left ventricular function during palpation of the tumour. However, ventricular dysfunction was transient in all instances and management was not influenced directly by pulmonary wedge pressure and cardiac output data. Thus, it would appear that these data, although interesting, are critical only in certain patients, such as those whose cardiovascular status is already compromised before operation.

CONCLUSION

Phaeochromocytoma may simulate any hypertensive syndrome. Although it is an uncommon cause of high arterial pressures, its recognition is important because of serious anaesthetic problems if the diagnosis is missed before any surgical procedure. Preoperative preparation with alpha- and beta-adrenergic blocking drugs is recommended by most authors, although no controlled study has been undertaken regarding their efficacy in the prevention of intraoperative cardiovascular disturbances. It should be mentioned that, in expert hands, the operative mortality does not appear to have been influenced by preoperative alpha- and beta-adrenergic blockade. However, preoperative therapy is mandatory in patients with sustained or paroxysmal hypertension. In these patients, prazosin was effective in our recent experience.

Virtually all anaesthetic agents and techniques have been used successfully and the choice of a specific agent is of secondary importance. The depth of anaesthesia is more important, since it can inhibit adrenergic and cardiovascular responses to noxious anaesthetic and surgical stimuli. The major factor responsible for reduction in operative mortality is control of hypotension by fluid replacement rather than by use of catecholamines following removal of the phaeochromocytoma.

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