Hypertension and renal dysfunction in primary hyperparathyroidism: effect of parathyroidectomy

A. K. SALAHUDEEN*, T. H. THOMAS*, L. SELLARS*, S. TAPSTER*, P. KEAVEY†,
J. R. FARDON†, I. D. A. JOHNSTON‡ AND R. WILKINSON*

Departments of *Medicine, †Medical Physics and ‡Surgery, University of Newcastle upon Tyne, Newcastle upon Tyne, U.K.

(Received 18 January/4 July 1988; accepted 19 July 1988)

SUMMARY

1. Twenty-four patients with primary hyperparathyroidism were studied before and 18 restudied 6.5 months (mean) after parathyroidectomy, to investigate the pathogenesis of the hypertension which may accompany this condition. Comparison was made with age-matched patients with essential hypertension and with normotensive control subjects.

2. There was a significant inverse relationship between mean arterial pressure and $^{51}$Cr-labelled ethylene-diaminetetra-acetate ($^{51}$Cr-EDTA) clearance in patients with hyperparathyroidism both before and after parathyroidectomy, but not in patients with essential hypertension.

3. Creatinine clearance appeared to overestimate glomerular filtration rate in some patients with hyperparathyroidism, falling significantly after surgery while $^{51}$Cr-EDTA clearance was unchanged. This observation may explain the failure of some previous studies to relate hypertension to impairment of renal function.

4. Plasma renin activity, plasma aldosterone and whole-body exchangeable sodium did not differ between normotensive and hypertensive patients with primary hyperparathyroidism and were unchanged after surgery.

5. Parathyroidectomy did not result in any change in blood pressure or in glomerular filtration rate measured by $^{51}$Cr-EDTA clearance.

Key words: hyperparathyroidism, hypertension, parathyroidectomy, renal function.

Abbreviations: $C_{Cr}$, creatinine clearance; $^{51}$Cr-EDTA, $^{51}$Cr-labelled ethylenediaminetetra-acetate; iPTH, immunoreactive parathyroid hormone; MAP, mean arterial pressure; PA, plasma aldosterone; PRA, plasma renin activity; PTH, parathyroid hormone.

Correspondence: Dr R. Wilkinson, Ward 4, Freeman Hospital, Newcastle upon Tyne NE7 7DN, U.K.

INTRODUCTION

The inclusion of serum calcium in many routine biochemical screening tests has shown that primary hyperparathyroidism is less rare than was thought. In a routine health check in Stockholm, a prevalence of 0.36% was found [1], and it is more common with increasing age and in women [2]. Hyperparathyroidism and hypertension have been linked in that there is an increased prevalence of hyperparathyroidism in hypertensive patients, up to 1% [3], and of hypertension in patients with primary hyperparathyroidism [4, 5]. In a series detected by routine screening of hospital referrals, the relative risk of hypertension [blood pressure $>$ 160/95 mmHg (21.3/12.7 kPa)] was 1.98 [2]. The mechanism of this hypertension is not understood, since the evidence on the role of impairment of renal function [1, 3, 5], hypercalcaemia [1, 6, 7], the sympathetic nervous system [8] and the renin-angiotensin system [6, 9, 10] is conflicting. There is also controversy as to whether parathyroidectomy improves hypertension. Some studies show cure or improvement in a proportion of patients, [5, 6, 11], but others, including our own previous studies, report no significant change in blood pressure after surgery [10, 12–15].

Like hypertension, the prevalence of impairment of renal function in patients with hyperparathyroidism depends on the source of the patients studied. Of those detected during population screening, 13% had impaired renal function [1], whereas in hospital-referred patients creatinine clearance ($C_{Cr}$) of $<$ 79 ml/min was found in 35% [5]. Parathyroidectomy probably has little effect on renal function [12], but there have been reports of falls in inulin clearance and $C_{Cr}$, and of increases in serum urea and creatinine after surgery [5, 14].

This study was designed to investigate the role of the renin-angiotensin-aldosterone system, whole-body exchangeable sodium and renal function in the pathogenesis of hypertension in hyperparathyroidism and the effect of surgery on blood pressure and renal function.
EXPERIMENTAL

Patients

Twenty-four patients with primary hyperparathyroidism in whom the diagnosis was made on the basis of hypercalcaemia without other cause and elevated or normal (non-suppressed) serum immunoreactive parathyroid hormone (iPTH) levels, and who had been referred to the endocrine surgery unit over a period of 9 months, were studied. In all cases the diagnosis was confirmed by removal of a parathyroid adenoma with correction of hypercalcaemia. Eighteen patients were re-studied 5-8 (mean 6.5) months after parathyroidectomy. Comparison was made with 16 patients with essential hypertension attending the medical outpatient clinic, in whom blood pressure was comparable with that of the hypertensive hyperparathyroid patients, and 19 normal subjects previously studied in the Department of Nephrology. The age and sex distribution of the three groups is shown in Table 1. The protocol of the study was approved by the Ethics Committee of the Newcastle Health Authority.

All drugs which might interfere with renal function, blood pressure, whole-body exchangeable sodium or the renin–angiotensin system were withdrawn at least 2 weeks before the studies. The patients continued on normal diet throughout and were studied as inpatients.

Methods

Renal function was measured by 24 h $C_{\text{Cr}}$ in all patients and by the technique of a single injection of $^{51}$Cr-labelled ethylenediaminetetra-acetate ($^{51}$Cr-EDTA) [16] followed by taking venous blood samples at 2, 3, 4, and 6 h after injection in patients with hyperparathyroidism and essential hypertension, but not in normal controls.

Whole-body exchangeable sodium ($Na_\text{e}$) was measured by isotope dilution using 15 $\mu$Ci of $^{24}$Na and a 22 h equilibration period and was expressed in relation to lean body mass [17]. Plasma samples for measurement of plasma renin activity (PRA) and plasma aldosterone (PA) were drawn at 09.00 hours after overnight fasting and recumbency, and between 11.00 and 12.00 hours after ambulation. PRA was measured by estimation of angiotensin I generation [18, 19] (RIANEN Angiotensin I kit; New England Nuclear). The coefficient of variation was 9.2% intra-assay and 14.2% inter-assay. Aldosterone was extracted from plasma into dichloromethane, purified by descending paper chromatography and measured by radioimmunoassay [20]. The coefficient of variation was 8.4% intra-assay and 9.6% inter-assay. The antiserum S85 was a generous gift from Professor Benraad, University of Nijmegen, Nijmegen, The Netherlands. Fasting samples were also drawn for the measurement of plasma urea, creatinine, sodium, potassium, chloride, urate (not in normal controls) and total calcium, which were determined using standard Technicon autoanalyser methods. Ionized calcium was measured in fasting plasma samples with an Orion SS20 analyser until October 1982 and with a Radiometer ICA 1 thereafter. iPTH was determined by radioimmunoassay of fasting plasma samples employing Burroughs Wellcome antiserum 211/32 (MRC Reagent

<table>
<thead>
<tr>
<th>Table 1. Comparison of MAP, renal function, $Na_\text{e}$, PRA and PA in normotensive control subjects, essential hypertensive patients and patients with hyperparathyroidism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbreviations: ANG I, angiotensin I; LBM, lean body mass. Results are means ±SD or means and 95% confidence limits converted from normally distributed log values (PRA and PA) or means (range) (age). Statistical significance: $\pm P&lt;0.005$ for hyperparathyroid patients compared with normotensive controls.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Sex (no. of males)</td>
</tr>
<tr>
<td>MAP (mmHg) (kPa)</td>
</tr>
<tr>
<td>Plasma creatinine (µmol/l)</td>
</tr>
<tr>
<td>Plasma urea (mmol/l)</td>
</tr>
<tr>
<td>Creatinine clearance (ml min$^{-1}$ 1.73 m$^{-2}$)</td>
</tr>
<tr>
<td>$^{51}$Cr-EDTA clearance (ml min$^{-1}$ 1.73 m$^{-2}$)</td>
</tr>
<tr>
<td>Serum urate (mmol/l)</td>
</tr>
<tr>
<td>PRA (pmol of ANG I min$^{-1}$ 1$^{-1}$)</td>
</tr>
<tr>
<td>Supine</td>
</tr>
<tr>
<td>Erect</td>
</tr>
<tr>
<td>PA (pmol/l)</td>
</tr>
<tr>
<td>Supine</td>
</tr>
<tr>
<td>Erect</td>
</tr>
<tr>
<td>$Na_\text{e}$ (mmol/kg LBM)</td>
</tr>
</tbody>
</table>
Hypertension in hyperparathyroidism

which is primarily directed against the N-terminal region of the parathyroid hormone (PTH) molecule, and bovine PTH standard 71/324 (National Institute for Biological Standards and Control, Potters Bar, Herts., U.K.). The system included an intact molecule (1-84) bovine PTH tracer (Wellcome Laboratories) and a solid-phase second antibody. At the level of iPTH of 3 units/l, the coefficient of variation was 5% intra-assay and 10% inter-assay.

Blood pressure was taken by a single observer (A.K.S.) on three occasions, the first at 12.00 hours on the first day of study, and the others at 09.00 hours and 12.00 hours on the next day. The mean of the three readings was used. A standard mercury sphygmomanometer was used, pressure was recorded after 5 min in the recumbent position, phase V of the Korotkov sounds was taken as diastolic pressure and for the analysis, mean arterial pressure (MAP), i.e. diastolic plus one-third of pulse pressure, was used.

Statistical analysis

When data were normally distributed, paired or unpaired Student's t-test and analysis of variance was used to determine the effect of subject groups and posture. PRA and PA were analysed as their logarithms to achieve normal distribution and the results are expressed as the logarithmic mean and 95% confidence limits (± 2 SD of log distribution). When data were not normally distributed, paired or unpaired Wilcoxon's rank-sign test was used. For some data the distribution was normal when the whole group was considered but not when hypertensive and normotensive patients were analysed separately. Mean and SD are used to describe normally distributed data, and median and range when distribution was not normal. When P values exceeded 0.05, differences are considered to be non-significant and the P value is not quoted.

RESULTS

Effect of parathyroidectomy

Parathyroidectomy corrected hyperparathyroidism in all cases. Serum total calcium fell from 2.89 ± 0.18 to 2.34 ± 0.11 mmol/l (P < 0.001) and ionized calcium from 1.54 ± 0.1 to 1.21 ± 0.05 mmol/l (P < 0.001). Serum iPTH was also significantly reduced from 1.1 (median) (range 0.2-3.5) to 0.3 (0.2-1.3) units/l (P < 0.01).

MAP (supine) for the group as a whole did not change significantly after surgery, being 99 ± 17 mmHg (13.2 ± 2.3 kPa) before and 101 ± 19 mmHg (13.4 ± 2.5 kPa) after parathyroidectomy. There were no changes in either supine systolic blood pressure (132 ± 21.5 mmHg (17.6 ± 2.9 kPa) before and 138 ± 30.9 mmHg (18.4 ± 4.1 kPa) after parathyroidectomy) or supine diastolic blood pressure (80 ± 14.7 mmHg (10.6 ± 2.0 kPa) before and 81 ± 15.2 mmHg (10.8 ± 2.0 kPa) after parathyroidectomy). Of the 18 patients studied before and after surgery, four were hypertensive before and five after parathyroidectomy. MAP rose by > 5 mmHg (0.7 kPa) in nine patients, fell by > 5 mmHg in five patients and changed by < 5 mmHg in three.

There was a significant inverse relationship between recumbent MAP and 51Cr-EDTA clearance in all patients with hyperparathyroidism studied before parathyroidectomy (r = -0.476, P < 0.05, Fig. 1a), and in the 18

Fig. 1. Relationship between recumbent MAP and 51Cr-EDTA clearance in (a) 24 patients with hyperparathyroidism studied before parathyroidectomy (r = -0.476, P < 0.05) and (b) 18 patients studied after parathyroidectomy (r = -0.75, P = 0.0003). Regression lines are shown. To convert mmHg to kPa, divide by 7.5.
patients studied post-operatively \((r=0.75, P=0.0003,\) Fig. 1b). Although there was a similar relationship between MAP and \(C_{\text{Cr}}\) after parathyroidectomy \((r=-0.53, P=0.025)\), this was not seen before parathyroidectomy \((r=+0.20)\).

Plasma creatinine rose slightly from \(88 \pm 25\) to \(92 \pm 28\) \(\mu\)mol/l \((P<0.05)\) and plasma urea significantly from \(4.9 \pm 1.3\) to \(5.5 \pm 1.4\) mmol/l \((P=0.001)\) after parathyroidectomy. \(C_{\text{Cr}}\) fell significantly from \(85 \pm 25\) to \(76 \pm 27\) ml min\(^{-1}\) 1.73 m\(^{-2}\) \((P=0.001)\) after parathyroidectomy; however, \(51\text{Cr}-\text{EDTA}\) clearance did not change \((79 \pm 24\) and \(79 \pm 26\) ml min\(^{-1}\) 1.73 m\(^{-2}\)) although there was good agreement between \(C_{\text{Cr}}\) and \(51\text{Cr}-\text{EDTA}\) clearance both before and after surgery, \(C_{\text{Cr}}\) was clearly higher in 16 patients before surgery and tended to fall towards the line of identity after surgery (Fig. 2).

There was a close correlation between 24 h urinary creatinine excretion in 18 patients studied before and after parathyroidectomy \((r=+0.82, P<0.003)\), suggesting that urine collections were probably complete.

Serum urate measured in 17 patients before and after parathyroidectomy fell significantly from \(0.36 \pm 0.09\) to \(0.33 \pm 0.07\) mmol/l \((P=0.02)\).

PRA, PA and \(\text{Na}_c\) did not change after surgery (Table 2).

Comparison of normotensive and hypertensive patients with hyperparathyroidism

MAP in the hypertensive hyperparathyroid patients was \(124 \pm 10.1\) mmHg \((16.5 \pm 1.3\) kPa) and in the normotensive patients \(92.6 \pm 13.4\) mmHg \((12.3 \pm 1.8\) kPa). \(51\text{Cr}-\text{EDTA}\) clearance was lower in the eight hypertensive [supine diastolic blood pressure > 100 mmHg \((13.3\) kPa)] than in the 16 normotensive patients with hyperparathyroidism [median 55 (range 28–93) vs 81 (37–138) ml min\(^{-1}\) 1.73 m\(^{-2}\), \(P=0.04,\) Fig. 3]. The hypertensive and normotensive subjects did not differ in age \((59.9 \pm 12.3\) vs \(54.8 \pm 13.6\) years).

The difference in \(C_{\text{Cr}}\) between the hypertensive and normotensive patients with hyperparathyroidism [median 71 (range 39–107) vs 85 (21–137) ml min\(^{-1}\) 1.73 m\(^{-2}\)] did not reach significance.

No differences were observed in PRA, PA or \(\text{Na}_c\) between hypertensive and normotensive patients with hyperparathyroidism (Table 2), and there was no significant relationship between MAP and PRA, PA and \(\text{Na}_c\) or between PRA and \(\text{Na}_c\).

Serum urate was higher in the hypertensive patients with hyperparathyroidism than in normotensive patients [median 0.41 (range 0.31–0.52) vs 0.32 (0.24–0.51) mmol/l, \(P=0.004\)]. The level in the hypertensive patients was also significantly higher than in the group of essential hypertensive patients studied [median 0.33 (range 0.19–0.49) mmol/l, \(P=0.01\)].

There were no differences in serum total calcium, ionized calcium, phosphate or iPTH between hypertensive and normotensive patients with hyperparathyroidism [total calcium: median 2.88 (range 2.64–3.07) vs 2.87 (2.59–3.30) mmol/l; ionized calcium: median 1.55 (range 1.46–1.64) vs 1.52 (1.45–1.85) mmol/l; phosphate: median 0.69 (range 0.42–0.87) vs 0.8 (0.58–1.11) mmol/l; iPTH: median 1.2 (0.2–2.3) vs 0.8 (0.2–3.5) units/l; all \(P>0.05\) and none was significantly related to MAP.

Comparison of patients with hyperparathyroidism with essential hypertensive patients and normal controls

Details of blood pressure and laboratory data in the 19 normal control subjects and the 16 patients with essential hypertension are shown in Table 1. MAP in the essential hypertensive patients \([119 \pm 28\) mmHg \((15.8 \pm 3.7\) kPa)] did not differ from that in the hypertensive hyperparathyroid patients \([124 \pm 10.1\) mmHg \((16.5 \pm 1.3\) kPa)].
Table 2. PRA, PA and whole-body Na\textsubscript{w} in patients with hyperparathyroidism before and after parathyroidectomy and in normotensive and hypertensive patients with hyperparathyroidism

<table>
<thead>
<tr>
<th>Hyperparathyroid patients</th>
<th>Normotensive hyperparathyroid patients</th>
<th>Hypertensive hyperparathyroid patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before parathyroidectomy</td>
<td>After parathyroidectomy</td>
</tr>
<tr>
<td>PRA (pmol of ANG I min\textsuperscript{-1} l\textsuperscript{-1})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine</td>
<td>5.6 (1.0-30.9) (n=18)</td>
<td>4.9 (1.2-19.5) (n=18)</td>
</tr>
<tr>
<td>Erect</td>
<td>16.2 (3.9-67.6) (n=18)</td>
<td>10.5 (2.2-50.1) (n=18)</td>
</tr>
<tr>
<td>PA (pmol/l)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine</td>
<td>135 (54-337) (n=17)</td>
<td>107 (42-274) (n=17)</td>
</tr>
<tr>
<td>Erect</td>
<td>256 (93-701) (n=17)</td>
<td>164 (59-454) (n=17)</td>
</tr>
<tr>
<td>Na\textsubscript{w} (mmol/kg LBM)</td>
<td>54±10 (n=16)</td>
<td>54±8 (n=16)</td>
</tr>
</tbody>
</table>

There were no significant differences in PRA, PA or Na\textsubscript{w} among the three groups, except for ambulant PRA which was significantly higher in patients with hyperparathyroidism than in normotensive control subjects but not than in essential hypertensive patients (Table 1). There was no correlation between PRA and Na\textsubscript{w} either before or after parathyroidectomy, nor in essential hypertensive patients or normal controls. 51Cr-EDTA clearance in hypertensive patients with hyperparathyroidism was lower than in patients with essential hypertension [median 55 (range 28-93) vs median 91 (67-154) ml min\textsuperscript{-1} l.73 m\textsuperscript{-2}, P=0.004], as well as being lower than that in normotensive patients with hyperparathyroidism (Fig. 3).

Although there was a close correlation between C\textsubscript{Cr} and 51Cr-EDTA clearance in patients with hyperparathyroidism (r=C\textsubscript{Cr}=+0.86, P<0.001, Fig. 2) and in patients with essential hypertension (r=C\textsubscript{Cr}=+0.81, P<0.001), the difference in C\textsubscript{Cr} between the hypertensive patients with hyperparathyroidism [median 71 (range 39-107)] and the essential hypertensive patients [median 92 (range 40-176) ml min\textsuperscript{-1} l.73 m\textsuperscript{-2}] and the normotensive controls [median 85 (range 52-116) ml min\textsuperscript{-1} l.73 m\textsuperscript{-2}] did not reach significance. In essential hypertensive patients C\textsubscript{Cr} (99 ± 33 ml min\textsuperscript{-1} l.73 m\textsuperscript{-2}) and 51Cr-EDTA clearance (98 ± 25 ml min\textsuperscript{-1} l.73 m\textsuperscript{-2}) did not differ.

Unlike the situation in hyperparathyroidism, there was no relationship between MAP and 51Cr-EDTA clearance in patients with essential hypertension (r=MAP=-0.26, P>0.05).

DISCUSSION

Hypertension is more common in hyperparathyroidism than in the general population [2, 4, 5]. The mechanism of this increase in blood pressure is not clear. Although calcium infusion may result in an increase in blood pressure [7], especially in patients with impaired renal function [21], this is not a universal finding [6] and it is unlikely that hypercalcaemia was the direct cause of hypertension in our patients, since blood pressure did not fall after parathyroidectomy despite correction of hypercalcaemia. For the same reason, it is unlikely that elevated levels of PTH in the serum could be directly responsible. More-
over, animal work suggests that PTH may have vasodilator and hypotensive effects rather than a pressor effect [22]. Furthermore, our hypertensive and normotensive patients with hyperparathyroidism did not differ with respect to serum total or ionized calcium, phosphate or iPTH and, like others [4], we found no correlation between blood pressure and serum calcium in patients with hyperparathyroidism. This is in contrast to the situation in essential hypertension where a significant positive correlation between blood pressure and total serum calcium has been described [23-25]. However, the role of calcium in essential hypertension is not clear, since serum ionized calcium appears to be either unrelated [26] or even inversely related [27] to blood pressure.

Calcium stimulates the release of renin from cortical slices of the rat kidney [28], suggesting the possibility that hypertension in hyperparathyroidism might be mediated through hypersecretion of renin. However, calcium infusion does not stimulate renin secretion in vivo [29, 30] and blood pressure does not fall after saralasin infusion [9]. Both subnormal and increased PRA responses to frusemide have been found in hypertensive hyperparathyroid patients [9, 10]. In our patients, an increase in mean ambulant PRA above that in normotensive controls but not above that in patients with essential hypertension was found. The similarity in all other respects to the control groups, the lack of difference between normotensive and hypertensive patients and the absence of change after parathyroidectomy provide strong evidence against a role for renin or aldosterone in the hypertension of hyperparathyroidism.

One of the earliest studies [5] concluded that renal damage was of importance in the pathogenesis of hypertension in hyperparathyroidism and often preceded the elevation of blood pressure. Subsequent studies questioned this as not all patients with impairment of renal function were hypertensive [1, 3, 11]. Our findings of a significant inverse relationship between blood pressure and %Cr-EDTA clearance both before and after parathyroidectomy provides support for the original conclusion of Hellstrom et al. [5]. Cc, [1, 3] or plasma creatinine [11] was used as the measure of renal function in earlier studies and this may have masked a reduction in renal function, since the present work has shown that in relation to %Cr-EDTA clearance, Cc, and plasma creatinine appeared to overestimate glomerular filtration rate in some patients with hyperparathyroidism. In normal subjects, the effect of tubular secretion of creatinine tends to balance the effect of overestimation of plasma creatinine by the Jaffé reaction so that Cc, approximates to inulin clearance. In hyperparathyroidism, tubular secretion of creatinine may be increased, since PTH inhibits proximal tubular permeability [31]. In addition, since PTH inhibits proximal reabsorption of sodium [32] and bicarbonate [33], it results in an increase in tubular flow and may therefore reduce tubular reabsorption of creatinine [34] and increase Cc,. In keeping with these reported effects of PTH we observed a significant increase in plasma urea and an insignificant rise in plasma creatinine in our patients after parathyroidectomy.

An increased incidence of hyperuricaemia and gout have been reported in hyperparathyroidism [34, 35], with serum urate usually falling after surgery without a change in Cc,. [36, 37]. We have confirmed the fall in serum urate without a rise in glomerular filtration rate after surgery. This suggests that PTH may reduce tubular secretion of urate as well as inhibiting reabsorption of sodium and phosphate.

Although an increase in glomerular filtration rate measured by inulin clearance has been reported in patients with hyperparathyroidism, falling after parathyroidectomy [37], in our patients glomerular filtration measured by %Cr-EDTA clearance did not change after parathyroidectomy.

The absence of a significant relationship between blood pressure and %Cr-EDTA clearance in our patients with essential hypertension suggests that the reduction in renal function in hyperparathyroidism may have been the primary event rather than being secondary to the hypertension. However, the kidney may be more susceptible to damage from hypertension in the presence of elevated serum PTH and calcium so that it remains possible that the renal impairment in hyperparathyroid patients was secondary. If impairment of renal function was the primary event, the way in which it led to elevation in blood pressure is not clear, since we have found no increase in whole-body Na and no difference in the renin–angiotensin–aldosterone system between patients with hyperparathyroidism and those with essential hypertension.

Thus from the parameters measured we have not been able to determine the exact pathogenesis of the hypertension in hyperparathyroidism, but impairment of renal function does appear to be of central importance. A fall in inulin clearance, Cc, and p-aminomhippurate clearance after parathyroidectomy without a fall in tubular maximal secretion of p-aminomhippurate has been reported [5], suggesting a pre-operative hyperperfusion and hyperfiltration, but no loss of nephrons after surgery. The observations of an increase in plasma urea in nine of 52 patients after parathyroidectomy is consistent with this [17]. However, there has been a report of a slight increase in clearance of inulin after parathyroidectomy with no increase in clearance of p-aminomhippurate [12]. Our observation of no change in %Cr-EDTA clearance therefore is in keeping with the general experience that parathyroidectomy does not significantly improve renal function.

There have been conflicting reports on the blood pressure response to parathyroidectomy. Only one group has reported cure of hypertension in all cases [4]; others have reported cure or improvement in blood pressure in between 20 and 50% of patients [5, 6, 11, 38, 39], although worsening of hypertension after surgery has been reported in some patients [5, 14, 15]. Like us, others have reported no change in mean blood pressure for groups of patients studied before and after parathyroidectomy [10, 12, 13, 40] and Posen et al. [41] found no difference in the prevalence of hypertension in patients cured of hyperparathyroidism compared with those with
unsuccessful surgery or not subjected to surgery. The apparently conflicting results may simply reflect the method of analysis, since although mean blood pressure was unchanged by surgery in our patients, MAP fell by more than 10 mmHg (1.4 kPa) in three patients. By whatever method of analysis, however, it is the general experience that surgery does not improve hypertension in the majority of patients.

No randomized prospective study of the value of surgery in hyperparathyroidism has been performed, but in a retrospective study [41] the clinical course of surgically cured cases did not differ from those with continuing disease and progression of renal failure may be uncommon in untreated cases [42]. These reports, together with our observations, suggest that hypertension cannot be used as an indication for surgery in patients with otherwise uncomplicated mild hyperparathyroidism.

ACKNOWLEDGMENT

We are grateful to Dr J. H. Dewar, Supraregional Assay Service, Royal Victoria Infirmary, Newcastle upon Tyne, for assay of iPTH.

REFERENCES