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An audit of the preoperative investigation of surgical patients

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The pattern of preoperative investigation was audited in 256 patients entering hospital for elective surgery over a 12-week period. During the initial 6 weeks (phase one), no guidance was given to the house surgeons and the investigations were assessed as being 'indicated' or 'not indicated' according to preset criteria. A total of 272 investigations was performed on 117 patients.

Minor modifications were made to the criteria. At the beginning of the second 6-week period (phase two), the modified criteria were distributed to the house surgeons as a guide to preoperative investigation. During this time 308 investigations were performed on 136 patients.

The number of investigations (excluding ECGs) that were available at the time of surgery rose significantly ($P < 0.001$) from 66% in phase one to 81% in phase two. The percentage of investigations deemed to have been indicated rose significantly ($P < 0.001$) from 53% in the first phase to 90% in the second phase. It is calculated that in practice 94% of the maximum possible savings of £7080 could be achieved over the course of 1 year by implementing these criteria for preoperative investigations.

Most patients entering hospital for elective surgery undergo 'routine' investigations. These tests may be requested to aid the management of the patient's clinical condition or more frequently as a screening test to detect unsuspected abnormalities sufficient to merit a change in surgical or anaesthetic management. Many of these tests, requested by inexperienced junior staff without guidance, are unnecessary and rarely influence clinical management.

A selective approach to preoperative investigations is desirable both to educate young clinicians as to which tests are relevant and to minimise unnecessary expenditure.

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Methods and patients

The pattern of requests of the five most commonly performed investigations was examined. The investigations were: full blood count (FBC), urea and electrolytes (U&E), blood glucose, chest radiograph (CR) and electrocardiogram (ECG). In phase one of the study, the established practice in requesting these preoperative investigations was analysed. All patients admitted to the hospital for elective surgery over a 6-week period under the care of the four general surgeons were studied. Patients undergoing day-case surgery and emergencies were excluded. The preoperative investigations performed on each patient were recorded on the evening of surgery; each investigation was documented as normal or abnormal and it was recorded whether an abnormal result had induced an alteration in clinical management. Each investigation was then classified as being either 'indicated' or 'not indicated' according to criteria derived from the literature (*1–6*). The indications for CR had already been established in this hospital and were in use at the time the study was conducted. ECGs were interpreted 'blind' at the end of the study by a Medical Senior Registrar (RR).

In phase two of the study, after minor modifications had been made in the criteria for performing these investigations, these criteria were circulated to the house surgeons. They were informed that their performance in observing these criteria would be monitored. The house surgeons were regularly informed of their performance throughout this part of the study. The same approach to data collection was adopted as in the first part of the

study. Data were again collected over a period of 6 weeks.

Statistical analysis was performed using the χ^2 test.

Criteria for investigations for phase 1

Chest radiology

1. Patients scheduled for cardiopulmonary surgery.
2. If clinical examination suggests that a malignancy or pulmonary TB is a strong possibility. When pulmonary TB in the patient's ethnic group is more than 1:1000 and when there has been no CR for 6 months.
3. Acute respiratory symptoms.
4. Chronic cardiopulmonary disease and no CR for 6 months (as a baseline for postoperative complications).

Full blood count

1. Age 60 years or over.
2. Major surgery involving cross-matching of blood for transfusion.
3. Abnormal blood loss, haematological disease, known or suspected anaemia.
4. Radiotherapy, chemotherapy or other immunosuppression.
5. Potential haemoglobinopathy.
6. Pregnancy.
7. Renal or liver disease.
8. Sepsis.

Urea and electrolytes

1. Age 60 years or over.
2. Diuretic therapy.
3. Renal disease.
4. Fluid and electrolyte disorders including vomiting, diarrhoea, intestinal fistula and nasogastric aspiration.
5. ADH abnormalities.
6. Liver disease.
7. Sepsis.

Glucose

1. Diabetes mellitus or pancreatic disease.
2. Hypoglycaemia.
3. Steroid treatment.
4. Gross obesity.
5. Hypothalamic, pituitary or adrenal disease.

Electrocardiogram

1. Age 50 years or over.
2. History of: chest pain,
   dyspnoea on exertion,
   orthopnoea,
   rheumatic fever,
   heart murmur.
3. History of cardiovascular or pulmonary disease.

Results

Phase 1

In all, 117 patients were admitted for elective surgery over the 6-week period, they underwent a total of 272 investigations. If ECGs are excluded (unreported traces are left on the ward) only 143 of the 218 (66%) requested investigations were available in the notes on the evening after surgery. Overall, 143 (53%) of the investigations were classified as being indicated on the above criteria.

Table I shows the results for the FBC. Three patients with indications for performing a full blood count had an abnormal result. Two of these patients had colorectal tumours; they were anaemic and required preoperative transfusion. The third patient had a haemoglobin of 10.5 g/dl; abdominal surgery for Crohn's disease was performed without resort to blood transfusion. An abnormal result was encountered in two patients in both of whom a preoperative FBC was not considered indicated; in one the haemoglobin was 17.4 g/dl and in a second mean cell volume was 97 fl, but neither abnormality necessitated a change in management. A full blood count was not performed in 18 patients, but in only five was an indication present for performing the investigation.

In the patients who had U&E estimation (Table II) only one abnormal result emerged, namely a low potassium in a patient on thiazide diuretics; in this patient a potassium infusion was administered on the evening before surgery and the operation proceeded as originally planned. In the 22 patients who did not have this investigation, the test was considered to be indicated in only six.

Table I. Full blood count results for phase 1 and phase 2

			Available for analysis	*Normal investigation*	*Abnormal investigation*
Investigations performed, phase 1 ($n=99$)	Indicated	48	36	33	3
	Not indicated	51	30	28	2
Investigations performed, phase 2 ($n=92$)	Indicated	83	75	64	11
	Not indicated	9	8	8	0

Table II. Urea and electrolyte results for phase 1 and phase 2

			Available for analysis	*Normal investigation*	*Abnormal investigation*
Investigations performed, phase 1 ($n=95$)	Indicated	39	27	26	1
	Not indicated	56	32	32	0
Investigations performed, phase 2 ($n=91$)	Indicated	82	64	59	5
	Not indicated	9	8	8	0

Table III. Glucose results for phase 1 and phase 2

			Available for analysis	*Normal investigation*	*Abnormal investigation*
Investigations performed, phase 1 ($n=10$)	Indicated	3	3	1	2
	Not indicated	7	4	3	1
Investigations performed, phase 2 ($n=6$)	Indicated	2	2	0	2
	Not indicated	4	3	2	1

Table IV. Chest radiograph results for phase 1 and phase 2

			Available for analysis	*Normal investigation*	*Abnormal investigation*
Investigations performed, phase 1 ($n=14$)	Indicated	10	8	6	2
	Not indicated	4	3	3	0
Investigations performed, phase 2 ($n=27$)	Indicated	25	13	11	2
	Not indicated	2	2	2	0

Table V. ECG results for phase 1 and phase 2

			Available for analysis	*Normal investigation*	*Minor abnormality*	*Major abnormality*
Investigations performed, phase 1 ($n=54$)	Indicated	43	43	26	2	3
	Not indicated	11	11	10	1	0
Investigations performed, phase 2 ($n=89$)	Indicated	83	83	57	26	0
	Not indicated	6	6	4	2	0

The two abnormal glucose results (Table III) in the indicated group were both mildly elevated values in known diabetic patients. In the group where the investigation was not indicated there was one mildly elevated value in a patient undergoing surgery for peripheral vascular disease. Of 107 patients who did not have this investigation performed, an indication was present in three.

The results for CR are shown in Table IV. The two abnormalities in the indicated group were old changes following a thoracoplasty in one case and pneumonia in the other. In the group of 103 patients who did not have a chest radiograph, 20 had an indication for the examination, in the majority this was surgery for early breast cancer.

Two patients were found to have ECGs showing acute ischaemia (Table V). On reviewing the notes one had similar changes in 1987, but in the second patient the ECG changes were new, being absent in an ECG performed 4 months previously. In a third patient, a sinus bradycardia of 43 beats/min with atrial extrasystoles was recorded, but there was no record of the abnormality. No action was recorded in the notes as having been taken as a result of any of these abnormalities. ECGs were not performed in 63 patients, but indications (mainly age) were present in 19 of these cases.

Criteria modifications

After analysis of the phase 1 results, minor modifications were made to the criteria for investigating patients. The indications for performing both FBC and U&E were widened to include all patients undergoing grouping and saving of blood preoperatively and those patients having blood cross-matched.

Phase 2

In all, 139 patients were entered into the second phase of the study and 305 investigations were performed. A significantly greater number of blood tests or CRs were available for analysis than in phase 1 (175 of 216; 81%; $P<0.001$). There were 275 (90%) investigations indicated according to the criteria, a significant increase on phase 1 ($P<0.001$).

There was a significant decrease in the number of FBCs that were performed in phase 2 but not indicated compared with phase one ($P<0.001$; Table I), and a significantly greater number were available for analysis ($P<0.001$). Seven patients were anaemic and four required transfusion preoperatively. One patient was mildly polycaethaemic. Two patients had mildly elevated white cell counts and a further patient had an elevated lymphocyte count due to known chronic myeloid leukaemia. In the 47 patients who did not have the test, indications were present in only two.

The number of 'not indicated' U&E tests in phase 2 was significantly less than in phase 1 ($P<0.001$; Table II) and a significantly greater number were available for analysis ($P<0.001$). Of the five abnormal results in the 'indicated' group, four were due to a mildly elevated urea. The fifth patient was hyponatraemic and this finding resulted in postponement of surgery until the abnormality was corrected. Only two patients had an indication for the investigation among the 48 who did not have it performed.

The two abnormal results for glucose estimations (Table III) in the 'indicated' group were both mildly elevated levels in known diabetic patients. In the 'not indicated' group, one patient being investigated before femoropopliteal bypass graft had a marginally raised glucose level. A total of 133 patients did not have the investigation and in none of these people was the test indicated. There was no significant difference between the results in phase 1 and phase 2.

Almost one-half of the CRs requested were not available on the evening of surgery (Table IV). There were only two minor abnormalities detected in the 'indicated' group. A CR was not performed in 112 patients, but there was an indication to perform it in 13, mainly patients with breast cancer as in phase 1 of the study. There was no significant difference between the results in phase 1 and phase 2.

There was a significant decrease in ECGs that were performed but not indicated in phase 2 ($P<0.01$; Table V). In the 50 patients who did not have the investigation, there was an indication to perform it in seven. There were no major abnormalities in either group.

Cost implications

Although the primary reason for performing this study was not financial, there may well be cost implications if this strategy for preoperative investigations is implemented. Extrapolating the figures from both phases of the study, 1109 patients would be expected to undergo elective surgery over the course of 1 year. The expected number of investigations performed over the course of 1 year was calculated firstly from the phase 1 figures, then the improved figures derived from phase 2, and finally the theoretical best possible performance was calculated. The prices used were those charged to private patients by the hospital and were £8.30 for any pathology test, £9.00 for a CR and £11.60 for an ECG. The figures involved are shown in Table VI. Although by following an ideal pattern of practice it would be possible to save just over £7080, in practical terms the savings would probably amount to just under the maximum at an estimated £6679. The number of tests requested could be reduced by 904 (29%) over the course of 1 year, but from the phase 2 figures the indications are that the reduction would be slightly less at 842 (27%).

Discussion

Unlike previous reports (*1–6*), the results in this study were collected on the evening of surgery. In the initial phase of the study it was revealed that 35% of the

Table VI. Estimated total number and cost of investigations for 1 year derived from the study

		Expected figures (phase 1)	*Improved figures (phase 2)*	*Best possible figures*
FBC	Number	1114	647	599
	Cost	£9246	£5370	£4972
U&E	Number	1172	599	555
	Cost	£9728	£4972	£4607
Glucose	Number	58	105	35
	Cost	£481	£872	£291
CR	Number	140	213	299
	Cost	£1260	£1917	£2691
ECG	Number	614	692	706
	Cost	£7122	£8027	£8190
Total	Number	3098	2256	2194
	Cost	£27837	£21158	£20757

investigations requested were not available to the surgical team or to the anaesthetist at the time of surgery. This proportion was significantly ($P < 0.01$) reduced to 19% in the second phase of the study, an improvement but still far from ideal. That major ECG abnormalities were apparently overlooked is worrying. This aspect of failure to ensure availability of results has not previously been noted, although it is well-recognised in practice.

A previous study *(1)* has shown that 1.3% of patients under the age of 60 years have an unsuspected abnormal haemoglobin result, rising to 6.1% over the age of 60 years. Our results confirm the former figure; moreover, none of the mildly abnormal results in this group resulted in a change of management. Charpak *et al. (2)*, using their protocol for ordering investigations, found that 55% of their patients had the investigation performed with a relatively high rate of abnormalities (32%) but a change in treatment in only 7% of this group. Our figures show a much lower rate of abnormalities in the combined figures for both phases (13%) but leading to a change in treatment in a higher proportion, six of the 14 patients (43%).

Two previous studies that looked at U&E found no abnormal results in the under 40 years age group *(3)* and the under 60 years group *(1)*. We elected to use the older cut-off point to keep the age the same as for haemoglobin estimations without detecting any abnormal results. An American study *(4)* using similar criteria to this study found only 0.2% abnormal results, again confirming the relative safety of this set of recommendations.

Few plasma glucose tests were requested in our study. There was one minor abnormality in both phases of the study in patients with vascular disease; consequently this indication was added to the final list now given to the housemen. Four out of the five glucose investigations that were indicated were abnormal which is a similar proportion to the 75% of patients in the French study *(2)* and reflects the known diabetic patients in both series.

Several studies on the value and utilisation of chest radiology have already been carried out in Cardiff and South Wales. These have resulted in the abandonment of routine preoperative chest radiography. The guidelines agreed between the departments of radiology and anaesthetics in this hospital are similar to those produced by the Royal College of Radiologists *(5)*. The success of this approach is demonstrated by the relatively few unindicated investigations requested in this study. Although the majority of CRs were available in phase 1, only just over one-half were present on the ward in the second part, this may be attributable to the delays caused by reporting films in the radiology department. These delays might be overcome by returning unreported films to the ward, but since major ECG abnormalities were unrecognised in this study it is likely that errors would also be made in the interpretation of CRs.

The lower age limit for performing ECGs has varied from 40 years *(3)* through 50 years *(6)* to 60 years *(1)*, no study having found any major abnormality in patients younger than the chosen age limit. This finding is again confirmed in our study, since only one minor abnormality was encountered in an asymptomatic patient under the age of 50 years.

The percentage of tests considered to be indicated rose from 53% in the first phase of the study to 90% in the second phase. This confirms that it is possible to improve the performance of junior doctors provided they are given specific guidance on requesting investigations. Implementation of such guidelines should achieve about 90% of the maximum projected cost savings, but in the long term the active involvement of senior clinicians would be essential.

Neither part of the study showed any major abnormalities in those investigations that were performed but considered 'not indicated'. This confirms that the indications chosen were broadly correct. This audit has shown that selective ordering of investigations for patients

before surgery is feasible and safe and may reduce both workload and cost.

References

1 McKee RF, Scott EM. The value of routine preoperative investigations. *Ann R Coll Surg Engl* 1987; **69**: 160–2.

2 Charpack Y, Blery C, Chastang Cl *et al.* Usefulness of selectively ordered preoperative tests. *Med Care* 1988; **26**: 95–104.

3 Catchlove BR, Wilson RMacL, Spring S, Hall J. Routine investigations in elective surgical patients. *Med J Aust* 1979; **2**: 107–10.

4 Kaplan EB, Sheiner LB, Boekmann AJ *et al.* The usefulness of preoperative laboratory screening. *JAMA* 1985; **253**: 3576–81.

5 The Royal College of Radiologists. Preoperative chest radiology. *Lancet* 1979; **2**: 83–6.

6 Patterson KR, Caskie JP, Galloway DJ, McHinnie DL. The preoperative electrocardiogram: an assessment. *Scott Med J* 1983; **28**: 116–18.

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