ORIGINAL PAPER

Measurement of haemoglobin as a screening test in general practice

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Objective: To assess the validity of using the measurement of haemoglobin as a primary screen test at point-of-care in general practice.
Methods: 1100 consecutive full blood counts carried out at Hammersmith Hospital haematology laboratory on blood samples sent by the general practitioners in the area were reviewed. Where haemoglobin was in the normal range all the parameters of a full blood count were checked and a blood film was screened in order to identify any abnormal features occurring in the absence of anaemia.
Results: Haemoglobin was normal in 81% of the samples, and in 81% of this set none of the blood count components showed any abnormal features (i.e. outside two standard deviations of normal reference range).The remaining 19% of cases included 32 with iron deficiency, 26 with high MCV, 84 with leucocyte abnormalities (neutrophilia, neutropenia, lymphocytosis, eosinophilia,monocytosis) and 19 with platelet counts either too high or too low. The predictive value of a normal full blood count from a normal haemoglobin was 0.81. However, when the limits of normal reference values were set at three standard deviations only 7% of the cases showed abnormal features and the predictive value of normality from a normal haemoglobin increased to 0.92.
Conclusion: There are now simple and suitable devices available for measuring haemoglobin at point-of-care, away from a laboratory. This provides a useful screening test in general practice as a full blood count would, as a rule, be required only in the small proportion of cases where anaemia is detected or the patient's history and/or clinical signs specifically indicate the need for this further investigation. This approach should contribute to more efficient, convenient and economical practice without compromising clinical management.

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There are obvious advantages in having results of basic laboratory tests on hand when a patient is first seen, and previous generations were familiar with the side-room tests carried out in the hospital ward as soon as a patient was admitted. This facility was lost with the advent of centralised laboratory services and the use of increasingly sophisticated analysers. However, in recent years the importance of point-of-care testing (POCT) is again becoming recognised and facilitated by the development of small table-top analysers which are usually precalibrated, require minimal maintenance, are simple to use and provide results for all the parameters which comprise a full blood count in a single process. Thus, in a number of countries POCT has become well established in primary health care clinics and doctors offices, notably in the USA where 90% of family doctors and general physicians have an office facility for certain analytical tests.[1] They are, however, relatively expensive, as are the reagents. In the UK POCT is found mainly within hospitals as an adjunct to the central laboratory where rapid results are especially important e.g. in critical care units and anticoagulant clinics. Guidelines have been published on the management of POCT in general, and specifically in haematology.[2,3]

The full blood count is the most common screening test in general practice. Blood samples are usually collected at a phlebotomy service and are despatched from there to the laboratory. As a rule results will be returned to the practitioner within 24 hours. The basic cost, including specimen collection, laboratory charges and issue of a test report is on average £5; however, the cost to the community must also take account of the economic effects of the patient having to be seen again when the test results are available. This includes further loss of working time, possible problems with transport arrangements etc., whilst the service provided by the community physician within the limits of available time will be compromised, resulting in delays for any patients trying to make appointments to be seen.

Thus, the potential usefulness of having the full blood count, or particular components of the count, carried out as a POCT in general practice requires appraisal. For measuring haemoglobin alone there are now several devices which are portable, easy to handle and simple to use, considerably cheaper than blood count analysers and as they require only one drop of capillary blood they are eminently suitable for use in doctors' offices.[4] These include the well established HemoCue (Hemocue AB, Ängelholm, Sweden) which provides a result within two minutes and is accurate within 1–2%.[5,6] The instrument costs £375 and each test costs £0.47. Another device is the pocket-sized WHO Haemoglobin Colour Scale which is intended for clinical anaemia screening by providing readings of haemoglobin within 1 g/dl of the true value in under a minute.[7,8] Having been developed primarily by WHO to meet the needs of developing countries, it is low-priced, and now available commercially (COPAK GmbH, Oststenbeld, Germany) with the permanent Scale costing $5 (£3) and each test strip 1.5 cents (about one penny).

The question which arises is whether haemoglobin alone is adequate as the primary screen in general practice. On the assumption that only patients with low haemoglobin need

follow-up with a full blood count, does the haemoglobin screen significantly reduce the number of blood counts; conversely, do any significant abnormalities occur despite a normal haemoglobin? This study has been undertaken to assess the adequacy of haemoglobin alone rather than a full blood count as the initial screening test. In interpreting the significance of abnormal results for any of the blood count parameters, it must be appreciated that 5% of the healthy population could be expected to have results outside 2 standard deviations (SD) and 1% outside 3SD of the normal mean values. It is thus debatable under what circumstances a result just outside the 2SD range might be regarded as significant in providing a better understanding of a patient's clinical state.

METHODS

The local general practitioners in a suburban district of London with an ethnic and economically mixed population routinely send their patients' blood samples to the Hammersmith Hospital laboratory for blood counts. In a window of these practices, 1100 sequential samples received by the laboratory were assessed. These excluded patients with known serious diseases under hospital treatment requiring mandatory full blood counts, established haemoglobinopathies and women attending the antenatal clinic. During this study no blood samples were received from infants.

Diagnosis of anaemia was based on haemoglobin <130 g/l for men and <120 g/l for women.[9] Abnormal blood count features were identified as results outside 2SD or 3SD of the normal reference values established in the laboratory (Table 1). The clinical utility of the test was calculated by Galen and Gambino's method, using the numbers of true and false positive and negative results, respectively, to estimate the sensitivity of haemoglobin measurement, its predictive value and overall diagnostic efficiency.[10]

RESULTS

Haemoglobin was normal in 895 of the 1100 cases (81.3%) and in 726 (81.1%) of these cases with normal haemoglobin no abnormal features were found in any parameters of the blood count. In the remaining 169 (18.9%) cases, various abnormal blood count parameters outside 2SD of normal values were found (Table 2). The main abnormal red cell features were lower mean cell volume (MCV) associated with lower mean cell haemoglobin (MCH) with or without MCH concentration (MCHC) (Table 1). These features were indicative of pre-anaemic iron deficiency; the majority of these patients presented to their doctors with non-specific complaints, especially tiredness or fatigue. Most of the 29 patients with leucocytosis had non-specific complaints; ten presented with pharyngitis (2), bronchitis (2), joint pains (3) and loose stools/diarrhoea (3). There were 80 cases where the differential count showed a reversed neutrophil to lymphocyte ratio, but in 60% of these the absolute counts were normal, and in some cases with neutrophilia or lymphocytosis, the total leucocyte count was not significantly increased. A high proportion of the 'abnormal' results were only just outside 2SD and the majority were within 3SD of the normal reference values shown in Table 1. The subset outside 3SD (Table 2) included only 28 cases with red cell abnormalities, 33 with abnormal leucocyte counts, together with two patients with thrombocytopenia and six with thrombocytosis. Thus, a full blood count might have contributed to the patient's clinical diagnosis in only 7.5% of the patients with a normal haemoglobin in this set. Conversely, it is of interest to note fourteen cases with haemoglobin higher than normal which were shown to have increased red cell count and packed cell volume; most of these were associated with diuretic therapy, and they were correctly diagnosed from haemoglobin alone. One case was subsequently found to have true polycythaemia with platelet count >500x10⁹/l.

Table 3 shows the sensitivity, predictive value and clinical utility of haemoglobin as a screening test. Within 2 SD limits there was a sensitivity of 0.93 with a positive predictive value of 0.81. Within 3SD limits the sensitivity was 0.86 with positive predictive value of 0.92, while the overall diagnostic efficiency of haemoglobinometry was 80–82%.

Table 1 Values used in this study for normal reference ranges at 2 SD (and 3SD)*

Reference	Range
Haemoglobin (g/l)	Men 130–170; women 120–150
Red cell count ($\times 10^{12}$/l)	Men 4.5–5.5 (4.2–5.8); women 3.8–4.8 (3.5–5.1)
Packed cell volume	Men 0.40–0.50 (0.37–0.53); women 0.36–0.46 (0.34–0.49)
MCV (fl)	83–101 (78–106)
MCH (pg)	27–32 (25–33)
MCH (%)	32–35 (30–36)
Platelets ($\times 10^9$/l)	100–450 (60–500)
Total leucocyte count ($\times 10^9$/l)	4–10 (3–12)
Differential count ($\times 10^9$/l)	
Neutrophils	2.0–7.0; i.e. 40–80%
Lymphocytes	1.0–3.0; i.e. 20–40%
Monocytes	0.2–1.0; i.e. 2–10%
Eosinophils	0.02–0.5; i.e.1–6%
Basophils	0.02–0.1; i.e. <1–2%

* Adapted from Lewis SM, Bain BJ, Bates I. *Dacie & Lewis Practical Haematology* 9th ed. London: Churchill Livingstone, 2001

Table 2 Blood samples (n=895) with normal haemoglobin but abnormal blood count parameters outside 2SD and 3SD of reference values

Abnormal parameter	Number of samples >2 SD<	Number of samples >3 SD<
High PCV		
Men	5	0
Women	2	2
Low MCV and MCH		
With low MCHC	17	17
With normal MCHC	15	0
High MCV	26	9
Platelets		
<100×10⁹/l	3	2
>450×10⁹/l	16	6
Leucocytosis*	29	22
Neutrophilia	20	19
Lymphocytosis	30	3
Leucopenia	43	2
Neutropenia	29	2
Lymphopenia	5	0
Monocytosis	4	2
Eosinophilia	6	4
Basophilia	3	3
Abnormal features	169 (18.9%)	69 (7.7%)
No abnormal features in blood count	726 (81.1%)	826 (92.3%)

* In some cases with absolute neutrophilia or lymphocytosis, the total leucocyte counts were still within normal 2SD limits

DISCUSSION

There are obvious advantages in having a simple reliable test to detect anaemia at the point of care without having to undertake a venepuncture. This study has demonstrated the

Table 3 Clinical utility of haemoglobin as screening test

	2SD	3SD
True positive (Normal Hb with normal blood count)	726	828
False positive (Normal Hb with abnormal blood count)	169	69
True negative (Anaemia with abnormal blood count)	154	70
False negative (Anaemia with normal blood count)	51	135
Sensitivity (TP/(TP+FN))	0.93	0.86
Specificity (TN/(TN+FP))	0.48	0.50
Positive predictive value (TP/(TP+FP))	0.81	0.92
Clinical efficiency ((TP+TN)/Total number)	0.80	0.82

TP, true positive; TN, true negative; FN, false negative; FP, false positive. Positive, identifies normality by screening test

clinical utility of a haemoglobin screen in general practice. There were a small number of cases without anaemia in which diagnosis could have been helped by the full blood count, but in practice specific clinical features should indicate the need for the full blood count despite absence of anaemia. It is arguable whether this justifies a full blood count in all cases. It is recognised that this experience represents a window on one group of practitioners and may not be representative of all family practices, nor indeed of the same practices on other occasions.

Account must also be taken of the fact that the data were derived from haemoglobin measurements performed in the laboratory, but it is suggested that a similar level of accuracy and precision can be obtained with one of the simple haemoglobinometers such as the HemoCue which, with a short training session, can be used reliably by no technical staff in a clinic or general practice.[5] The WHO Haemoglobin Colour Scale which provides a reading of haemoglobin within 1 g/dl (10 g/l) of true value from a drop of blood in less than a minute, may also have a place as an appropriate clinical tool for this purpose[8], and it has the advantage that as it is pocket-sized and independent of a power source it is suitable for domiciliary practice. It should, however, be appreciated that collection of capillary blood from a finger by skin puncture must be performed by a standardised procedure.[11] Inadequate specimen collection with failure to obtain a free flow of blood from the puncture, necessitating the need to squeeze the finger too vigorously or to milk it to obtain the blood is the most likely cause of misleading results.

In this present study a full blood count was shown to be clinically helpful in only a small proportion of cases where anaemia was detected or when clinical signs and/or the patient's history indicated the need for such further investigation. It may be concluded that measuring haemoglobin alone is a valuable primary screening test and that limited selective requests from practitioners for full blood counts would contribute to efficient, convenient and economical practice; by test utility statistics haemoglobin was shown to be a sensitive screening test, giving a reliable prediction on the need for a full blood count, and it is thought to be unlikely that the diagnosis of a clinically significant condition will be missed by this practice. Thus, for example, while iron deficiency is relatively common in women and children, it is usually regarded as clinically significant only when anaemia is present. It is a matter for debate whether failure to do a full blood count rather than a haemoglobin screen in the first instance would be a concern for good clinical management. It would be valuable to obtain evidence for or against this premise by similar studies in other environments.

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