Urgent full blood count in children over 3 months of age with bacterial meningitis

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SUMMARY

Children with bacterial meningitis often have a full blood count (FBC) measured urgently on admission. We investigated whether urgent FBC gave results that aided immediate management or predicted outcome in children with meningitis. FBCs were measured on admission during 190 episodes of bacterial meningitis in children admitted between 1984 and 1991. Significant anaemia was found in seven children, but immediate transfusion was only necessary in the three subjects who were in the Paediatric Intensive Care Unit (PICU). A white blood count of less than $5 \times 10^9 \text{ L}^{-1}$ was significantly associated with death ($P < 0.02$), but a Glasgow Coma Score of less than 8 predicted death more accurately (positive predictive value of 40%). FBC yielded immediately useful information only in the 15% of children who were admitted to PICU. Conscious level was a better predictor of outcome than FBC. We recommend that urgent FBC should be performed in children with meningitis admitted to a PICU; in other children with meningitis FBC can be analysed during normal laboratory hours.

Key words: bacterial meningitis, blood count.

INTRODUCTION

The full blood count (FBC) is one of the most widely used tests in the evaluation of febrile children, and urgent FBCs are often performed on children admitted with bacterial meningitis. The FBC may provide clinically useful information in children with meningitis, and is recommended in some standard paediatric texts,¹ but not others.² Measurement of haemoglobin or platelet count may detect unsuspected anaemia or thrombocytopenia, which may require further investigation or treatment. A raised peripheral white blood cell count (WBC) is known to be significantly associated with bacterial infection, and differs between the meningeal pathogens.³ WBC may thus aid identification of the

organism causing meningitis. Haemoglobin, WBC and platelet count may also be of prognostic value.^{4,5} However, clinical features may be equally effective in identifying the causative organism or children with a poor prognosis.⁶ Many laboratories are now questioning whether an FBC, performed out of hours, provides any more useful information than would be obtained if the sample was analysed routinely the following day. If the FBC can be analysed routinely, the extra costs of the 'on-call' service can be avoided.

We have studied the results of FBC performed when children are admitted with bacterial meningitis. We aimed to determine what proportion had abnormal results that were immediately clinically relevant, and whether FBC could help to predict causative organism or death. We then hoped to identify those children with bacterial meningitis in whom an urgent FBC should be performed.

METHODS

Alder Hey Children's Hospital admits children from the Liverpool and South Sefton Health districts and receives tertiary referrals to the Regional Paediatric Intensive Care Unit (PICU) from other districts. Criteria for inclusion in this retrospective survey included the following: positive cerebrospinal fluid culture; age over 3 months; and admission between January 1984 and December 1991. Infections complicating ventricular shunts, myelomeningocoeles or after neurosurgery were excluded. Children were initially identified from laboratory records, and further cases were obtained from ward admission records and the records of other researchers⁷ (O. Marzouk, personal communication).

Clinical information and the results of the FBC taken on admission were extracted from case notes, using a standardized form, by one of us (F.A.I.R.).

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Definitions

The FBC results were compared with the hospital laboratory's reference ranges for age. Clinically relevant anaemia was defined as a haemoglobin value of 1 g or more below the lower limit of normal for age.⁸ A low platelet count was defined as less than $150 \times 10^9 \text{ L}^{-1}$. Clinically significant thrombocytopenia was defined as a platelet count of less than $50 \times 10^9 \text{ L}^{-1}$.

Signs and symptoms of meningitis were defined as neck stiffness, a bulging anterior fontanelle, and irritability or a depressed conscious level noted by the parents or admitting doctor. A petechial rash was a marker for septicaemia.

Descriptive and analytical statistics were performed on a personal computer using Arcus Pro-II version 2.15. Fisher's exact test and the Mann-Whitney *U*-test were used, and a *P*-value of less than 0.05 was defined as significant.

RESULTS

Cases

A total of 202 children admitted with 205 episodes of bacterial meningitis were investigated. The case notes of all but one child were eventually traced. However, the relevant information was missing from nine sets of case notes (including one child who died), and five other children were brought in dead, with only post-mortem details available. All these 14 children were excluded from the study, as no FBC results were available for them.

Information was therefore available for 190 episodes of meningitis, from which 15 children died. Platelet counts were not measured as part of the FBC during the early part of the study, and data were available for 125 episodes.

The median age of the children was 13 months (range 3–168 months). A total of 29 children (15%) were admitted to the PICU.

Meningitis was caused by the three common childhood pathogens, namely *Neisseria*

meningitidis ($n=106$), *Haemophilus influenzae* type b (Hib) ($n=58$), and *Streptococcus pneumoniae* ($n=26$) (see Table 3).

FBC results

Table 1 shows the proportion of children with results outside the laboratory reference ranges.

Haemoglobin was below the reference range in 51 out of 186 children (27%). However, only seven children (3.8%) were judged to have a clinically relevant anaemia with a haemoglobin level of 1 gdl⁻¹ or more below the lower limit of normal for age. A normochromic, normocytic blood film was seen in four of these children, three of whom were ventilated on the PICU and received immediate transfusions. The fourth child showed evidence of disseminated intravascular coagulation, and was also transfused several days after admission. Some time later he developed a chronic glomerulonephritis with a persisting anaemia. The remaining three children with clinically relevant anaemia had hypochromic, microcytic blood films. None were admitted to the PICU. Two of these children were investigated: one was found to have sickle cell trait and the other had iron deficiency.

The WBC was raised in 72 out of 190 children (38%). Only eight children did not show signs or symptoms of meningitis or septicaemia on admission. An abnormal WBC could thus have been an early marker for meningitis in these children. However, three children had a normal WBC ($5\text{--}14 \times 10^9 \text{ L}^{-1}$), one had a low WBC ($<5 \times 10^9 \text{ L}^{-1}$), and only four children had a raised WBC ($\geq 15 \times 10^9 \text{ L}^{-1}$).

Platelet count was low in 19 out of 125 cases (15%). Only one child had a platelet count of less than $50 \times 10^9 \text{ L}^{-1}$, and this result was thought to be spurious, due to a clot in the sample.

Prognostic factors

Of the haematological factors previously reported to be associated with mortality,^{4,5} only WBC below

Table 1. Results of full blood count (FBC) compared to reference range for age for children with bacterial meningitis

Parameter	Below reference range	Within reference range	Above reference range
Haemoglobin ($n = 186$)	51 (27)	128 (69)	7 (4)
White cell count ($n = 190$)	25 (13)	93 (49)	72 (38)
Neutrophil count ($n = 186$)	10 (5)	71 (38)	105 (56)
Platelet count ($n = 125$)	19 (15)	91 (73)	15 (12)

The number of children is shown, with percentage values in parentheses.

$5 \times 10^9 \text{ L}^{-1}$ was significantly associated with death ($P < 0.02$; Table 2). This was present in five of the nine deaths due to meningococcal disease. The positive predictive value for death was 26%, and death was more significantly associated with a Glasgow coma score of less than 8 on arrival (positive predictive value of 40%).

Establishing the causative organism

The results of FBC from children with meningitis with the three different causative organisms are shown in Table 3. Median WBC, neutrophil count and platelet count were all significantly higher in pneumococcal meningitis. However, the wide ranges of these results made it impossible to use any one of these tests to predict the causative organism.

A total of 79 children had a petechial rash, all of whom had meningococcal disease. Petechial rash was thus more useful than WBC in identifying the causative organism.

Table 2. Prognostic value of clinical signs and laboratory data for children admitted with bacterial meningitis

Clinical sign	Survivors (n = 175)	Deaths (n = 15)	P-Value
Coma*	13 (7)	9 (60)	0.000005
Laboratory values			
Haemoglobin $<1 \text{ Lg d l}^{-1}$	71 (41)	7 (47)	n.s.
White cell count $<5 \times 10^9 \text{ L}^{-1}$	14 (8)	5 (33)	0.02
Platelet count $<150 \times 10^9 \text{ L}^{-1}$	17 (10)	3 (20)	n.s.

The number of children is shown, with percentage values in parentheses.

*Coma = children with Glasgow Coma Score of <8 .

n.s. = not significant by Fisher's exact test.

Table 3. Clinical and laboratory data for causative organisms

Parameter	<i>Meningococcus</i> (n=106)	<i>Haemophilus</i> (n=58)	<i>Pneumococcus</i> (n=26)
Age (months)	14 (3.2–168)	12.5 (4–80)	11 (3.5–162)
Laboratory values			
Haemoglobin (gdl ⁻¹)	11.1 (7.2–15.3)	11 (7.4–14.4)	10.6 (8.5–14.3)
White cell count (10^9 L^{-1})	13.9 (1.7–37)	11.9 (2.1–47)	21.4 (2.9–58) [†]
Neutrophil count (%)	72 (12–95) [†]	74 (16–93)	82 (41–96) [†]
Platelet count (10^9 L^{-1})	248 (22–1160) [†]	209 (55–900)	336 (82–1200) [†]

The results are expressed as median values, with ranges in parentheses.

[†]Difference between *Pneumococcus* and *Haemophilus*, $P < 0.01$ by Mann-Whitney U-test.

[†]Difference between *Pneumococcus* and *Meningococcus*, $P < 0.01$ by Mann-Whitney U-test.

DISCUSSION

The purpose of performing urgent investigations in children with meningitis is to help establish the diagnosis, to identify the causative organism, to assess the prognosis and to identify any complications requiring immediate treatment. Our study shows that an urgent FBC fulfils few of these functions, and that clinical examination is more likely to provide useful information. Anaemia has been reported in bacterial meningitis, especially that due to Hib⁹. However, a marked anaemia was present in only seven children (4%) in our study, and urgent transfusion was only necessary in three children ventilated in the PICU. An urgent FBC is thus justified in children with meningitis admitted to the PICU.

WBC values were above the reference range in 38% of our cases. However, a raised WBC is similarly found in 39% of children at our hospital who undergo lumbar puncture and are found not to have meningitis or another bacterial infection (unpublished data). Signs or symptoms of meningitis were present in 96% of cases on arrival, and the diagnosis could have been made before an FBC was done. Only four out of eight children with no specific signs of meningitis had a raised WBC, confirming the insensitivity of this test as a predictor of meningitis.¹⁰

A raised WBC may help to identify febrile infants less than 3 months of age at increased risk of bacterial infection.¹¹ However, children less than 3 months of age were excluded from our study. Classical signs of meningitis (meningism or a raised fontanelle) are absent in more than 50% of these young infants, but other clinical features (irritability and seizures) may help to identify those with bacterial meningitis.¹²

WBC values were significantly higher in pneumococcal meningitis, as described previously,³ but this finding was not predictive of this organism due to the wide range of counts found with the other two organisms. The presence of a petechial rash, however, was highly predictive of meningococcal infection (79 out of 106 cases).

Mortality was associated with a low WBC (less than $5 \times 10^9 \text{ L}^{-1}$), but not with a low platelet count (less than $150 \times 10^9 \text{ L}^{-1}$) or a low haemoglobin value (less than 11 g dL^{-1}), in contrast to previous studies.^{4,5} However, a Glasgow coma score of less than 8 was a much better predictor of mortality in our study, and confirms the usefulness of this sign.⁶

FBC collected on admission in children with meningitis may identify a small number of children with concurrent pathologies (e.g. iron deficiency, haemoglobinopathies), as was found in our study. Children with bacterial meningitis may also develop thrombocythaemia or anaemia during treatment.⁹ It is therefore useful to analyse routinely an FBC collected on admission for abnormalities, and to compare it with subsequent results. However, frequent measurements of FBC in patients with infections are not recommended,¹³ and repeat FBC should only be requested if it is clinically indicated.

The cost of performing a FBC is small compared to the overall cost of treating children with meningitis. However, this cost may be increased by performing it out of hours, especially as 46% of cases are admitted out of hours (unpublished data). Although the cost per test is small, the cumulative costs, especially if performed out of hours, may be large if all children with suspected meningitis are included.

Our study suggests that an urgent FBC is justified only for those children with meningitis admitted to a PICU. Only 29 of the 190 children included in our study were in this category, implying that an urgent FBC need only be performed in 15% of children admitted with meningitis.

In conclusion, an urgent FBC is often measured in children with bacterial meningitis, but conditions requiring immediate treatment are only found in those admitted to the PICU. The physical signs of coma or a petechial rash are more predictive of outcome or causative organism than FBC results. Analysis of the FBC collected on admission could therefore be delayed if, as often happens, the child is admitted outside normal laboratory hours.

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