Annals of the Royal College of Surgeons of England (1979) *vol* 61

ASPECTS OF TREATMENT*

Surgery in children with homozygous sickle cell anaemia

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Summary

During the 25 years 1952–77 31 surgical procedures were performed on children aged up to 16 years with sickle cell anaemia (SCA). Six emergency operations were carried out, all for complications of SCA indistinguishable from the acute surgical conditions they mimicked. Seventeen minor operations were well tolerated and major surgery was undertaken 8 times, including 5 splenectomies for hypersplenism and increased transfusion requirements. The preparation for surgery by planned multiple transfusions and the indications for splenectomy are discussed. Recommendations are made for the preparation of patients for acute and routine surgery.

Introduction

Sickle cell anaemia (SCA) is the commonest serious haemoglobinopathy. It is estimated that there are 1200 persons suffering from the disease in Great Britain and that a further 80 000 persons carry the trait. King's Health District in south-east London provides medical care for the largest population of children with SCA in Europe[1,2]. It has therefore become important for surgeons working in this area to recognise this disease with its protean manifestations and in particular its ability to mimic acute surgical conditions.

It is now established that these patients need careful preparation before routine surgery to avoid sickling crises. Details of this preparation are not always well known, however, as in areas without a large negro population SCA is seen only rarely. In this paper we analyse our surgical experience of children with SCA during the past 25 years (1952–77) and describe their preoperative management.

Preparation for surgery

Since 1960 21 of the 23 routine surgical procedures performed have been preceded by transfusions. Packed red cells from compatible blood donated during the previous 7 days are transfused at weekly intervals until the level of haemoglobin-S in the peripheral blood is reduced to less than 30%. The response of a typical case is shown in Figure 1. When emergency surgery is required transfusion is started as soon as possible and continued during the operation, and the haemoglobin concentration is maintained above 10 g/dl thereafter until healing is complete.

Any pre-existing focus of infection is treated vigorously, and antibiotics are always administered prophylactically. All children are preoxygenated with 100% oxygen immediately before induction of anaesthesia, and oxygen administration is continued by mask for 24 h after the operation. Chest physiotherapy is given every 4 h during the day.

Alkalinisation with sodium bicarbonate intravenously has not been used as it is difficult to achieve under clinical conditions, and although there is experimental evidence that cells in vitro are protected from sickling in an alkaline environment, there is no justification for the assumption that the same effect occurs in vivo. Similarly dextrans, urea, cyanate, and magnesium sulphate have been avoided. Much more importance has been

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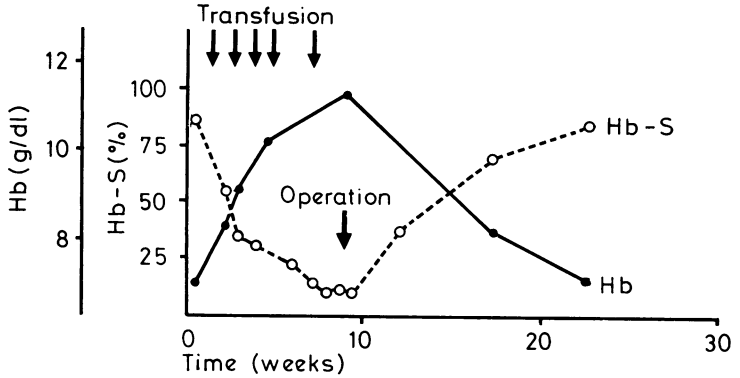

FIG. 1 *Effect of weekly transfusions of packed cells on haemoglobin level and percentage of circulating haemoglobin-S in a child undergoing preparation for orchidopexy.*

placed on adequate preoperative preparation by transfusion, the prevention of dehydration, hypoxia, and hypothermia, and the avoidance of tourniquets, spinal anaesthesia, and postural hypotension.

Results

EMERGENCY SURGERY

Before 1960 routine surgery was thought to be hazardous in the patient with SCA, and 3 of the 4 operations performed between 1952 and 1960 were emergencies. In subsequent years there was a greater awareness of the ability of SCA to mimic intra-abdominal emergencies and the frequency of acute surgery has therefore diminished.

Emergency surgery has been performed on only 6 occasions in the whole study. Each time minor occlusive episodes in bone or the splanchnic capillary bed have mimicked acute infection. Thus the 3 appendices removed were histologically normal and exploration of long bones for osteomyelitis proved negative on all 3 occasions. Two-thirds of these children, undergoing relatively minor acute surgery, developed postoperative complications of fever with or without chest infection (see table).

ELECTIVE SURGERY

Splenectomy was performed on 5 occasions, together with cholecystectomy if gallstones were present. Cholecystectomy alone was performed once. These major procedures were all preceded by adequate transfusion, but in spite of this minor chest complications developed in 2 cases and in another localising signs together with a Gram-positive septicaemia led to exploration of the left subphrenic space. No abscess was found and a staphylococcus was eventually isolated from an intravenous cannula. Drip-site infections have been particularly common in these children. The indications for splenectomy in this condition are either true hypersplenism, which is rare, or increased transfusion requirements, which occur in children who do not undergo the more usual 'autosplenectomy' by multiple episodes of spontaneous infarction. The beneficial effect of splenectomy is illustrated in Figure 2. In this patient the haemoglobin level was increased by approximately 3 g/dl.

One child underwent resection of middle and lower lobes for bronchiectasis. Recovery was complicated by a temporary collapse of

Results of operation in 31 children with SCA

Operation	*No*	*Prepared by transfusion*	*Complications*
Emergency appendicectomy	3	0	2
Emergency bone exploration	3	0	2
Splenectomy/cholecystectomy	6	6	3
Lobectomy for bronchiectasis	1	1	1
Elective caesarean section	1	1	1
Excision of breast lumps	2	1	1
Tonsillectomy/adenoidectomy	7	5	0
Other minor procedures	8	8	0

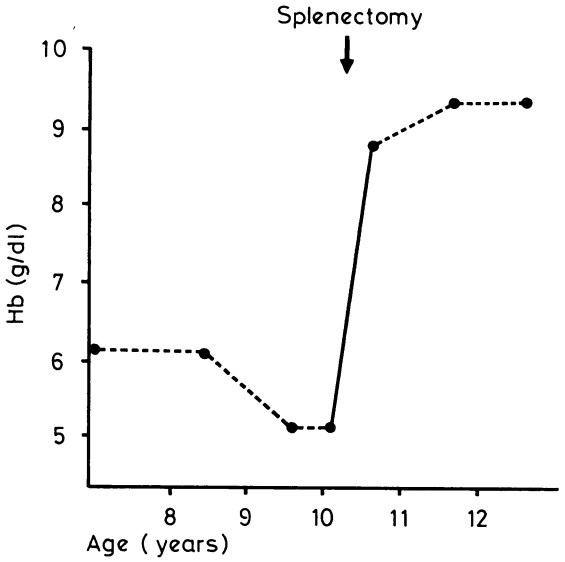

FIG. 2 *Effect of splenectomy on haemoglobin level of a child with SCA.*

the upper lobe, which responded promptly to antibiotics and physiotherapy.

Elective caesarean section was performed on one patient—a 16-year-old girl with absolute disproportion. Postoperatively there was unexplained fever and pneumonitis but recovery was otherwise uneventful.

One of the 2 patients having breast lumps excised was not transfused preoperatively and subsequently developed a chest infection. The child prepared by transfusion made an uncomplicated recovery.

Children with SCA are particularly prone to recurrent upper respiratory tract infections[3] and may require tonsillectomy and adenoidectomy. This was performed without complication on 7 occasions; 2 patients did not receive preoperative transfusion as part of their preparation.

Eight children underwent a variety of minor procedures, including herniotomy, orchidopexy, and squint correction, without postoperative complication.

Discussion

The abnormality of red cell formation in SCA results from the substitution of valine for glutamic acid in position 6 of the β-polypeptide chain of the globin component of the haemoglobin molecule. This alters the electrical charge on the molecule and causes the formation of crystals and tactoids when acidosis or hypoxia occurs. The cells become deformed and irregular and many adopt a sickle shape, which can cause stasis in capillary beds. The presence of haemobglobin-F as the major haemoglobin component affords some protection during the first few months of life.

Because of excess haemolysis of the abnormal cells and their entrapment within the spleen the child with SCA is anaemic, the haemoglobin concentration averaging 7 g/dl, and there is an associated reticulocytosis. Chronic haemolysis can cause pigment gallstone formation and increased haemopoiesis leads to expansion of the bone marrow space in the skull and long bones. Repeated microthromboembolic episodes in the pulmonary arterial tree may cause cor pulmonale, and the ventilation–perfusion defects which follow infarction further reduce the oxygen saturation of the haemoglobin. Cardiomegaly is present in 70–90% of patients owing to increased cardiac output associated with the anaemia and expanded plasma volume. Ischaemic damage to the renal medulla causes defects in concentrating ability and it is therefore important to remember that the specific gravity of the urine will not be helpful as a guide to fluid balance. Hepatosplenomegaly is a common finding in these children, but repeated infarction usually causes the spleen to shrink as the child grows. Pigment gallstones have been reported in 6–37% of cases of SCA, depending on the average age of the patients in the series[4]. Reticuloendothelial paralysis by red cell debris and functional splenectomy by multiple infarction lead to a degree of immunosuppression in these children, lowering their resistance to pneumococcal pneumonia and meningitis, salmonella osteomyelitis, and pyelonephritis from a variety of organisms. Local infarcts may become infected, causing liver abscesses or osteomyelitis.

Various crises may be superimposed on the general ill health of the child with SCA. Infection often precipitates infarctive (occlusive) crises which present as painful episodes due to blocking of capillary beds with dam-

aged red cells. In bone these episodes closely mimic osteomyelitis, while changes in the splanchnic bed may simulate appendicitis or cholecystitis. Most minor episodes respond to bed rest, intravenous fluids, oxygen, and antibiotics. Progression to a full infarctive crisis is rare and is heralded by persistent pyrexia, spread of pain to involve all four limbs, chest, and abdomen, and a fall in PaO_2 to below 10 kPa (75 mm Hg). At this stage the administration of a fresh blood transfusion with packed cells is indicated. Haemolytic crises are usually secondary to systemic infections of pneumococcal or viral origin and are recognised by a marked fall in haemoglobin level with a corresponding rise in reticulocyte count. Aplastic crises are characterised by a fall in haemoglobin level without reticulocyte response. Most patients recover rapidly with treatment which includes blood transfusion, antibiotics, oxygen, warmth, and bed rest. The sequestration crisis carries the worst prognosis but is only seen in children under the age of 5 years; massive stasis and sickling within a rapidly enlarging spleen may reduce the haemoglobin level to 1–2 g/dl within 24 h and prove fatal unless blood transfusion is started immediately. These patients require central venous pressure monitoring, blood gas estimation every 2 h, and nursing in an intensive care unit[5].

Although SCA is rarely seen in Britain outside those centres with extensive local West Indian or African populations, with increasing mobility and dissemination of these traditionally inner-city dwellers a greater number of hospitals can be expected to be involved in their medical care in the future. All 6 of the emergency operations we have reported were performed for complications of SCA indistinguishable from the acute surgical conditions they mimicked. While we do not advocate a policy of withholding operation, we would suggest that a period of rehydration and rest in bed will distinguish between true infective disease and minor occlusive episodes in most cases. It has been claimed that transfusion in SCA is hazardous[6], with an increased risk of precipitating crises. This has not been our experience[7] or that reported elsewhere in recent years[8, 9]. Numerous transfusions have been associated with neither mortality nor immediate sickling crisis. We have found that planned transfusion preoperatively has enabled us to perform major surgery on children with SCA, and minor procedures would seem now to carry no more morbidity than in normal children. It is the reduction of the number of circulating red cells that are capable of sickling to a safe level of below 30%, usually about 15%, that makes these children as near to normal as possible by the time they come to surgery. Thus spared the risk of an acute sickling episode, they are better able to cope with the residual effects of their SCA. Preparation by transfusion has enabled major surgery to be performed on children in whom it would not previously have been considered. Splenectomy has seldom been recommended in children with SCA, but we have found it useful in those requiring repeated transfusions for anaemia shown to be due to entrapment of erythrocytes in the spleen. Postoperatively, all our 5 patients have shown a rise in haemoglobin level of 1–3 g/dl, which has enabled them to lead a reasonably active life without further transfusion.

Recognition of the problems of the patient with SCA and careful planned preparation by transfusion means that homozygous disease need no longer be considered a contraindication to surgery: indeed, these children appear to require more surgical treatment than the normal child.

We are indebted to Dr L R Davis, consultant haematologist, for his help.

References

1 Stroud, C E, personal communication.
2 Davis, L R, personal communication.
3 Spooner, T R, and Dark, A W (1974) *Laryngoscope, 84,* 506.
4 Flye, M W, and Silver, D (1972) *Surgery, 72,* 361.
5 Burrington, J D, and Smith, M D (1976) *Surgical Clinics of North America, 56,* 55.
6 Henderson, A B (1950) *American Journal of Medicine, 9,* 757.
7 Davis, L R (1974) *British Journal of Haematology, 21,* 363.
8 Macleod, J A J (1969) *Proceedings of the Royal Society of Medicine, 62,* 1095.
9 Brody, J I, Goldsmith, M H, Park, S K, and Soltys, H D (1970) *Annals of Internal Medicine, 72,* 327.