[8] Hansen, A. P., *Journal of Clinical Investigation*, 1971, **50**, 1806.
[9] Panisset, A., Kohner, E. M., Cheng, H., and Fraser, T. R., *Diabetes*, 1971, **20**, 824.
[10] Galton, D. J., Wilson, J. P. D., and Kissebah, A. H., *European Journal of Clinical Investigation*, 1971, **1**, 399.
[11] Fain, J. N., Kovacev, V. P., and Scow, R. O., *Endocrinology*, 1966, **78**, 773.
[12] Randle, P. J., Garland, P. B., Hales, C. N., and Newsholme, E. A., *Lancet*, 1963, **1**, 785.
[13] Galton, D. J., *The Human Adipose Cell: A Model for Errors in Metabolic Regulation*. London, Butterworths, 1971.
[14] Tulloch, B. R., Dyal, K., and Fraser, T. R., *Journal of Endocrinology*, 1970, **48**, XLVIII.
[15] Jackson, R. A., *et al.*, *Diabetes*, 1971, **20**, 214.
[16] Lewis, B., Mancini, M., Mattock. M., Chait, A., and Fraser, T. R., *Lancet*, 1971, **2**, 947.
[17] Tassopoulos, C. N., Barnet, D., and Fraser, R., *Lancet*, 1969, **1**, 1282.
[18] Sterky, G. C. G., Persson, B. E. H., and Larsson, Y. A. A., *Diabetologia*, 1966, **2**, 14.
[19] Harris, L. V., Albink, M. J., Van Eck, W. F., Man, E. B., and Peters, J. P., *Metabolism*, 1953, **2**, 120.
[20] Tuller, E. F., Mann, G. V., Scherkenleib, F., Rochrig, C. B., and Root, H. F., *Diabetes*, 1954, **3**, 279.
[21] Lloyd, J. K., Fosbrooke, A. S., Wolff, O. H., and Salt, H. B., *Lancet*, 1962, **1**, 1329.
[22] Baghdade, S., Porte, D., and Bierman, E., *Diabetes*, 1968, **17**, 127.
[23] Thomas, P. K., and Lascelles, R. G., *Quarterly Journal of Medicine*, 1966, **35**, 489.
[24] Chopra, J. S., Hurwitz, L. J., and Montgomery, D. A. D., *Brain*, 1969, **92**, 391.
[25] Gabbay, K. H., *Diabetes*, 1968, **17**, 239.
[26] Ward, J. D., Barnes, C. G., Fisher, D. J., Jessop, J. D., and Baker, R. W. R., *Lancet*, 1971, **1**, 428.
[27] Spiro, R. G., *New England Journal of Medicine*, 1963, **269**, 566, 616.
[28] Fraser, T. R., *Proceedings of the 4th Congress of the International Diabetes Federation, Stockholm*, 1967, p. 206.

Anaesthesia in Sickle-cell States: A Plea for Simplicity

K. A. ODURO, J. F. SEARLE

British Medical Journal, 1972, 4, 596–598

Summary

505 patients with various haemoglobinopathies were given a general anaesthetic between January 1970 and February 1972. One patient with haemoglobin SC disease and one patient with sickle-cell trait (HbAS) died postoperatively. Four other patients who were sickling positive, but whose genotypes were unknown, died, one from sickle-cell crisis precipitated by haemorrhage.

A simple anaesthetic technique together with good postoperative care can provide safe general anaesthesia for patients with sickle-cell states. A plea is made for simplicity in the anaesthetic management of these patients.

Introduction

Interest in the management of patients with sickle-cell conditions in the steady state, in crisis, and during anaesthesia has increased during the past seven years. It is generally accepted that general anaesthesia is hazardous in these patients, especially those with genotypes SS and SC. There have been reports from West Africa,[1 2] the West Indies,[3] and America[4] on the anaesthetic management of patients with haemoglobin S, although the total number of cases reported is relatively small. This paper concerns 505 patients with various haemoglobinopathies who were anaesthetized at Korle Bu Teaching Hospital, Accra, during the 26-month period January 1970 to February 1972.

Anaesthetic Technique

The anaesthetic management of patients with haemoglobin SS, SC, and S-beta-thalassaemia may be summarized as simple safe techniques, with adequate oxygenation, ventilation, maintenance of the circulating volume, and efficient postoperative care. Infections, malaria, helminthic infestations, and malnutrition are vigorously treated before operation. In elective patients folic acid is also given. If the haemoglobin concentration is less than 5 g/100 ml one or two units of blood are given about three days before operation.

Premedication is usually effected with atropine and promethazine. Promethazine provides sedation without respiratory depression. Respiratory depressant drugs are avoided. Preinduction oxygenation is given for at least five minutes. Induction is achieved with a sleep dose of thiopentone (except in very ill patients or children, where diethyl ether or halothane are used). If intubation is necessary this is performed after paralysis with a short-acting muscle relaxant. Breath-holding, laryngeal spasm, and struggling must be avoided during induction.

Anaesthesia is maintained with halothane or trichloroethylene and 50% nitrous oxide and oxygen. The patient is allowed to breathe spontaneously or ventilation is controlled, depending on the surgical procedure.

Adequate blood replacement is essential. In an earlier report[5] failure to maintain an adequate blood volume caused the death of two patients. This did not occur in the present series.

Early recovery of consciousness and of upper respiratory tract reflexes is important. Postoperatively oxygen is given through nasal catheters for 12 to 24 hours. The dangers of hypoxaemia in the postoperative period are well established,[6] and in patients with sickle-cell disease its importance cannot be over emphasized. Blood gas studies[7] in patients with abnormal haemoglobin syndromes showed that the arterial oxygen tension was significantly lower than in those with normal haemoglobin. This serves to emphasize the need for adequate oxygenation before, during, and after anaesthesia.

Present Study

During January 1970 to February 1972 inclusive 505 patients with haemoglobinopathies had a general anaesthetic. The distribution of the haemoglobinopathies is shown in Table I.

TABLE I—*Distribution of Genotypes among the 505 Patients*

	No. of Patients		No. of Patients
SS	17	SF high gene	1
SC	21	AS	257
S-beta-thalassaemia	2	AC	26
CC	1	Sickling positive, genotype unknown	180

Department of Anaesthesia, University of Ghana Medical School, P.O. Box 4236, Accra, Ghana
K. A. ODURO, M.B., F.F.A. R.C.S., Associate Professor
J. F. SEARLE, M.B., F.F.A. R.C.S., Senior Registrar

PATIENTS WITHOUT HAEMOGLOBIN A

Forty-two patients (25 females and 17 males) aged 1½ to 52 years did not have haemoglobin A. Anaesthesia was used on 51 occasions, ranging in duration from 12 minutes to 2 hours 45 minutes. The main surgical groups and haemoglobin concentrations are shown in Tables II and III.

TABLE II—*Analysis of Main Surgical Groups of the 42 Patients with Haemoglobin SS, SC, SF (high gene), and S-beta-thalassaemia*

	No. of Patients		No. of Patients
General surgery	5	Other orthopaedic	4
General surgical emergencies	6	Obstetric	3
Neurosurgery	4	Minor Surgery	9
Thoracotomy	1	Eyes	1
Sequestrectomy	8	E.N.T.	1

TABLE III—*Haemoglobin Concentrations in Patients with Haemoglobin SS, SC, S-beta-thalassaemia, and SF (high gene)*

Haemoglobin (g/100 ml)	5-6	-7	-8	-9	-10	-11	-12	-13
No. of patients ..	2	3	8	5	8	7	3	2

Only one patient died—a 22-year-old woman, genotype SC, haemoglobin 11·5 g/100 ml, with avascular necrosis of the head of the left femur. A McMurray osteotomy was performed under general anaesthesia, which lasted 1 hour 25 minutes. During the operation she was given 1 unit of blood and 500 ml of 5% dextrose. She died suddenly six hours after the operation. Post-mortem findings were those of a sickle-cell crisis. We are unable to say whether she had been given postoperative oxygen.

PATIENTS WITH HAEMOGLOBIN AS

Altogether 257 patients with haemoglobin AS were given a general anaesthetic. These patients covered the whole range of surgical procedures (apart from open heart surgery), including closed mitral valvotomy, thoracotomies, and craniotomies. One girl now aged 4 years has been given 25 uneventful anaesthetics during the past three years for the repair of a damaged larynx.

One patient died—a 46-year-old woman, genotype AS, haemoglobin 8·5 g/100 ml, with a large abdominal mass. Laparotomy showed an extensive necrotic, haemorrhagic mass arising from the lateral wall of the pelvis and fixed to the uterus. A biopsy specimen was taken. Anaesthesia lasted 20 minutes. Her blood pressure fell throughout the operation and she died 30 minutes later despite resuscitative measures.

SICKLING POSITIVE PATIENTS, GENOTYPE UNKNOWN

There were 180 patients in this group, four of whom died.

Case 1.—A 63-year-old woman, haemoglobin 10·2 g/100 ml, had a subtotal thyroidectomy for a very large nodular goitre. Postoperatively she bled profusely, developed respiratory obstruction and had a cardiac arrest. She was successfully resuscitated. The wound was explored and the bleeding stopped. Eight hours later she bled again and died despite resuscitative measures. Necropsy showed haemorrhage at the site of operation tracking into the posterior and superior mediastinum, massive subcapsular haematoma of the liver and sickle-cell crisis.

Case 2.—A 60-year-old man who was jaundiced and whose haemoglobin was 9·7 g/100 ml had a laparotomy for carcinoma of the head of the pancreas. A gastro-jejunostomy and cholecysto-jejunostomy were performed. The operation lasted three hours. He died 14 hours later. Necropsy showed an enlarged heart and pulmonary oedema. There was blood clot in the abdomen and the jejunum was full of blood.

Case 3.—A 70-year-old man had an above-knee amputation for diabetic gangrene of the right foot. Next day he was drowsy, jaundiced, and had developed a right-sided pneumonia. He died 26 hours after operation.

Case 4.—A 58-year-old man had a huge ventral hernia and a strangulated femoral hernia. Under epidural analgesia with bupivacaine a segment of gangrenous small bowel was resected. One week later he developed intestinal obstruction with perforation of the bowel. Under general aneasthesia lasting one hour small-bowel resection was done. He died 40 minutes after operation. Necropsy was not performed.

COMMENT

The mortality may be summarized as follows. One patient with haemoglobin SC disease died during postoperative management. One patient with sickle-cell trait died from causes not directly related to sickling. Four patients with unknown genotype died, one from sickle-cell crisis among other factors, and three from factors not related to sickling.

Discussion

It is the policy in this department to consider every African patient a potential sickler. During the 26 months under review 20,000 anaesthetics were given in this hospital (excluding orthopaedic and casualty outpatient anaesthetics). As one in five Southern Ghanaians have the sickle-cell gene[8] one would expect there to be some 4,000 sicklers among these patients. This indicates that routine laboratory screening, in Ghana at least, is a gigantic problem. While it is possible to screen all elective surgical patients, this is not so for emergency cases at the present time. One must therefore rely on the history, from either the patient or his relatives, and clinical signs. In Ghana anaemia alone is not necessarily suggestive of a haemoglobinopathy, as 45% of surgical patients have a haemoglobin concentration of less than 10 g/100 ml.[9] It is erroneously believed that patients with sickle-cell anaemia die young. This is not so in Ghana. The clinical manifestations of haemoglobinopathies were extensively discussed by Konotey-Ahulu.[10]

In patients with sickle-cell trait (HbAS) anaesthesia and surgery carry little if any more risk than in those with normal haemoglobin (Hb AA). One death was recorded by Schenk.[11] Oduntan and Isaacs[2] reported two deaths, but one patient had carcinoma of the stomach and the other was thought to have died from a pulmonary embolus. Oduro[5] reported no deaths among 190 cases of sickle-cell trait in this department, but it was suggested that dangers from anaesthesia could not be completely ruled out in these patients. Konotey-Ahulu[12] also warned about the risk of anaesthesia in patients with sickle-cell trait and rightly stated: "the same conditions which would cause crisis in patients with sickle-cell anaemia could, if pushed to a further unphysiological degree, also cause in vivo sickling in patients with sickle-cell trait. General anaesthesia is in my list of 16 well documented causes of sickle-cell crisis." But at least in this series these unphysiological conditions presumably did not occur. The 25 general anaesthetics in one patient in our series also indicate that the risk of anaesthesia in sickle-cell trait is small.

The use of particular drugs and techniques during anaesthesia have been advocated from time to time. Many methods have been used in the prevention and treatment of sickle-cell crisis, but few have been tested by controlled clinical trials.[13] Brown[3] and Gilbertson[1 14] recommended an alkalization regimen during anaesthesia. This is based on reports that alkalinization aborts and prevents sickle-cell crisis,[15 16] but other workers

have not found this to be so.[17] We have not used it, as its usefulness in preventing crisis has not been established. It has been suggested that bicarbonate should be used if the arterial pH shows some degree of acidosis.[3] But in developing countries, at least, facilities for blood gas analysis are rarely available.

Exchange transfusion has been recommended for the treatment of preoperative anaemia[14] and as a safe method of managing anaesthesia and surgery.[18] This is not practicable in regions where the incidence of haemoglobinopathies is highest, as the availability of blood is low. Furthermore, it is doubtful if it is necessary.

Urea has been used to prevent and treat sickle-cell crisis.[19 20] Urea breaks down hydrophobic bonds and thereby breaks down the crystals of haemoglobin S. This approach has been criticized because of the dehydration it may produce[21] and the problems of giving a large urea load to patients whose kidneys are already badly compromised.[22] This is currently the object of controlled trials.[23] At present it does not seem to have a place in anaesthetic management.

It is clear that with straightforward anaesthesia and good postoperative care general anaesthesia is safe in patients with sickle-cell states without the need to resort to other measures.

Appendix

Since this series was completed a patient with sickle-cell anaemia has been anaesthetized while in crisis.

A girl, aged 10 years was admitted with a five-day history of abdominal pain, fever and vomiting. On examination she was dehydrated and pale and had a temperature of 102°F (38·9°C) and a pulse rate of 130/min. The abdomen was distended, rigid, and tender. The liver was not palpable but the spleen was very large. A provisional diagnosis of enteric fever or sickle-cell crisis with splenic infarct was made. Sickling was positive and haemoglobin electrophoresis showed haemoglobin SS.

Five days after admission the haemoglobin concentration fell from 6 to 4·7 g/100 ml. Her condition then deteriorated rapidly and a diagnosis of splenic abcess was made. She was given 2 units of non-sickling blood, and the next day splenectomy was performed under general anaesthesia. The spleen contained multiple infarcts and abscesses. Two units of blood were given during the operation.

She made a rapid recovery and was discharged two weeks after operation.

Requests for reprints should be sent to J.F.S., Department of Anaesthetics, Guy's Hospital, London SE1 9RT.

References

1 Gilbertson, A. A., *British Journal of Anaesthesia*, 1965, **37**, 614.
2 Oduntan, S. A., and Isaacs, W. A., *British Journal of Anaesthesia*, 1971, **43**, 1159.
3 Brown, R. A., *British Journal of Anaesthesia*, 1965, **37**, 181.
4 Holzman, L., Finn, H., Litchman, H., and Hermel, M. H., *Current Researches in Anesthesia and Analgesia*, 1969, **48**, 566.
5 Oduro, K. A., *Anaesthesia*, 1969, **24**, 307.
6 Nunn, J. F., and Payne, J. P., *Lancet*, 1962, **2**, 631.
7 Oduntan, S. A., *British Journal of Haematology*, 1969, **17**, 535.
8 Konotey-Ahulu, F. I. D., *Ghana Medical Journal*, 1971, **10**, 241.
9 Searle, J. F., *Ghana Medical Journal*, 1972. In press.
10 Konotey-Ahulu, F. I. D., *East African Medical Journal*, 1969, **46**, 1.
11 Schenk, E. A. *Annals of Internal Medicine*, 1964, **60**, 465.
12 Konotey-Ahulu, F. I. D., *Lancet*, 1969, **1**, 267.
13 *Lancet*, 1971, **2**, 1069.
14 Gilbertson, A. A., *Proceedings of the Royal Society of Medicine*, 1967, **60**, 631.
15 Mortimer, S., Greenberg, M. D., and Kass, E. H., *Archives of Internal Medicine*, 1958, **101**, 355.
16 Hugh-Jones, K., Lehmann, H., and McAlister, J. M., *British Medical Journal*, 1964, **2**, 226.
17 Ho Ping Kong, H., and Alleyne, G. A. O., *British Medical Journal*, 1969, **3**, 271.
18 Macleod, J. A. J., *Proceedings of the Royal Society of Medicine*, 1969, **62**, 1095.
19 McCurdy, P. R., and Mahmood, C., *New England Journal of Medicine*, 1971, **283**, 992.
20 Nalbandian, R. M., Anderson, J. W., Lusher, J. M., Agustsson, A., and Henry, R. C., *American Journal of the Medical Sciences*, 1971, **261**, 325.
21 Desforges, J. F., *New England Journal of Medicine*, 1971, **284**, 913.
22 Konotey-Ahulu, F. I. D., *Lancet*, 1971, **2**, 1255.
23 Nalbandian, R. M., *New England Journal of Medicine*, 1971, **284**, 1381.

Hospital Topics

Surgical Aspects of Bacterial Endocarditis

T. A. H. ENGLISH, J. K. ROSS

British Medical Journal, 1972, **4**, 598–602

Summary

Forty patients with a previous history of bacterial endocarditis were treated surgically between December 1967 and August 1971. Of 28 patients who had elective valve replacements there were four hospital deaths and one late death. Seven patients underwent emergency operation for intractable heart failure before completion of antibiotic treatment, six survived operation and there was one late death. Six patients had operations for infection on pre-existing valve substitutes, of whom three were treated as emergencies. There were two hospital and no late deaths. 78% of all patients were alive and well four years to nine months after operation.

These results confirm that in addition to elective valve replacement surgery has an important role both in the treatment of intractable heart failure during the infective stage of bacterial endocarditis and in the eradication of infection on cardiac prostheses.

National Heart Hospital, London W.1

T. A. H. ENGLISH, M.B., F.R.C.S., Senior Surgical Registrar (present address: Papworth Hospital, Nr. Cambridge, CB3 8RE)

J. K. ROSS, M.S., F.R.C.S., Consultant Surgeon (present address: Wessex Cardiac and Thoracic Centre, Southampton Western Hospital SO9 4WQ)

Introduction

Prognosis in bacterial endocarditis improved dramatically with the introduction of effective chemotherapy.[1] The development