morbidity, surgery can be safe and effective in HIV-positive patients, without an increase in patient mortality.

References

1. Abt Associates. *The Impending Catastrophy: A Resource Book on the Emerging HIV/AIDS Epidemic in South Africa*. Johannesburg: Lovelife, 2000.
2. Dorrington RE. How many people are currently infected with HIV in South Africa? *S Afr Med J* 2002; **92:** 196-197.
3. Joshi VV, Powell B, Conor E, *et al*. Arteriopathy in children with AIDS. *Pediatr Pathol* 1987; **7:** 261-275.
4. Calabrese LH, Estes M, Yen-Liebermann B, *et al*. Systemic vasculitis in association with human immunodeficiency virus infection. *Arthritis Rheum* 1989; **32:** 569-576.
5. Du Pont JR, Bonavita JA, Di Giovanni RJ, *et al*. Acquired immunodeficiency syndrome and mycotic abdominal aneurysms: a new challenge? Report of a case. *J Vasc Surg* 1989; **10:** 254-257.
6. Sinzobahamvya N, Kalangu K, Hamel-Kalinowski W. Arterial aneurysms associated with HIV infection. *Acta Chir Belg* 1989; **89:** 185-188.
7. Nair R, Abded-Carrim ATO, Chetti R, Robbs JV. Arterial aneurysms in patients infected with human immunodeficiency virus: a distinct clinical pathology entity? *J Vasc Surg* 1999; **29:** 600-607.
8. Nair R, Jobbs JV, Naidoo NG, Woolgar J. Clinical profile of HIV-related aneurysms. *Eur J Vasc Endovasc Surg* 2000; **20:** 235-240.
9. Tudhope L, Van Marle J. Multiple arterial aneurysms in an HIV infected patient: retrovirus positivity established as aetiology by means of the polymerase chain reaction (Abstract). Vascular Association of South Africa Conference, Sun City, 8 - 12 August 1999.
10. Veller M, Pillay T, Abdool-Carrim AT, Britz R. Aneurysms in patients with HIV infection: Involvement of the carotid artery bifurcation (Abstract). 25th World Congress of the ISCVS, September 2001. *Cardiovasc Surg* 2001; **9:** 2.
11. Nair R, Chetty R, Woolgar J, *et al*. Spontaneous arterio-venous fistula resulting from HIV arteritis. *J Vasc Surg* 2001; **33:** 186-187.
12. Chetti R, Batitang S, Nair R. Large vessel vasculopathy in HIV positive patients: another vasculitic enigma. *Hum Pathol* 2000; **31:** 374-379.
13. Chi D, Henry J, Kelly J, *et al*. The effects of HIV infection on endothelial function. *Endothelium* 2000; **7:** 233-242.
14. Bloom EJ, Abrams DI, Rogers G. Lupus anticoagulant in the acquired immuno-deficiency syndrome. *JAMA* 1988; **256:** 491-493.
15. Lafevillade A, Alessi MC, Martin-Poizot I, *et al*. Protein S deficiency in HIV infection. *N Engl J Med* 1991; **324:** 1220-1224.
16. Von Kaulla E, Von Kaulla KN. Antithrombin III and diseases. *Am J Clin Pathol* 1967; **48:** 69-80.
17. Saber AA, Aboolian A, La Raja RD, *et al*. HIV/AIDS and the risk of deep vein thrombosis: a study of 45 patients with lower extremity involvement. *Am Surg* 2001; **67:** 645-647.
18. Behrens G, Dejam A, Schmidt H, *et al*. Impaired glucose tolerance and beta cell function and lipid metabolism in HIV patients under treatment with protease inhibitors. *AIDS* 1999; **13:** F63-70.
19. Savioz D, Chilkot M, Ludwig C, *et al*. Preoperative counts of CD4 T-lymphocytes and early postoperative infective complications in HIV positive patients. *Eur J Surg* 1998; **164:** 483-487.
20. Paiement GD, Hymes RA, LaDouceur MS, *et al*. Postoperative infections in asymptomatic HIV sero-positive, orthopaedic trauma patients. *J Trauma* 1994; **37:** 545-551.
21. Mellors JW, Rinaldo CR, Gupta P, *et al*. Prognosis in HIV-1 infection predicted by the quantity of virus in plasma. *Science* 1996; **272:** 1167-1170.
22. Tram HS, Moncure M, Tarnoff M, *et al*. Predictors of operative outcome in patients with human immunodeficiency virus infection and acquired immunodeficiency syndrome. *Am J Surg* 2000; **180:** 228-233.
23. Binderow SR, Cavallo RJ, Freed J. Laboratory parameters as predictor of operative outcome after major abdominal surgery in AIDS and HIV infected patients *Am Surg* 1993; **59:** 754-757.
24. Diettrich NA, Cacioppo JC, Kaplan G, Cohen SM. A growing spectrum of surgical disease in patients with human immunodeficiency virus/acquired immunodeficiency syndrome: experience with 120 major cases. *Arch Surg* 1991; **126:** 860-866.
25. Barbaro G. Cardiovascular manifestations of HIV infection. *J R Soc Med* 2001; **94:** 384-390.
26. Avidan MS, Joans N, Pozniak AL. The implications of HIV for the anaesthetist and the intensivist. *Anaesthesia* 2000; **55:** 344-354.
27. Savioz D, Lironi A, Zurbuchen P, *et al*. Acute right iliac fossa pain in acquired immunodeficiency: a comparison between patients with and without acquired immune deficiency syndrome. *Br J Surg* 1996; **83:** 644-646.
28. Guth AA, Hofstetter SR, Pachter HL. Human immunodeficiency virus and the trauma patient: factors influencing post-operative infectious complications. *Journal of Trauma, Injury, Infection and Critical Care* 2000; **41:** 251-256.
29. Centres for Disease Control and Prevention. Public health service guidelines for the management of healthcare workers exposure to HIV and recommendations for post-exposure prophylaxis. *Mor Mortal Wkly Rep* 1998; **47:** RR-7: 1-33.
30. Department of Health. *Guidelines On Post-exposure Prophylaxis For Healthcare Workers Occupationally Exposed to HIV*. London: Department of Health, 1997.
31. Palella FJ, Delaney KM, Moorman AC, *et al*. Declining morbidity and mortality amongst patients with advanced human immuno deficiency virus infection. *N Engl J Med* 1998; **338:** 853-860.

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SCREENING FOR CHILDHOOD ANAEMIA USING COPPER SULPHATE DENSITOMETRY

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Objective. To evaluate copper sulphate densitometry to screen for childhood anaemia in a primary care setting, with a view to identifying children requiring definitive diagnostic testing and treatment.

Design. A cross-sectional screening study. Results of densitometry with a copper sulphate solution of specific gravity (SG) 1.048, corresponding to a haemoglobin (Hb) concentration of 10 g/dl, were compared with laboratory Hb determination.

Setting. Outpatient department of Pretoria Academic Hospital (73 children) and a local crèche (27 children).

Subjects. One hundred consecutive children, aged between 6 months and 6 years, with informed written consent by parents.

Outcome measure(s). Accuracy of copper sulphate densitometry in screening for Hb concentration below 10 g/dl in terms of sensitivity, specificity, positive and negative predictive values, as well as likelihood ratio.

Results. The prevalence of anaemia (Hb < 10 g/dl) was 17% (95% confidence interval (CI) 10.2; 25.8). Copper sulphate densitometry had a sensitivity of 88.2% (95% CI 62.3; 97.9), a specificity of 89.2% (95% CI 79.9; 94.6), a positive predictive value of 62.5% (95% CI 40.8; 80.5) and a negative predictive value of 97.4% (95%CI 90.0; 99.5) in screening for anaemia. The likelihood ratio of a positive screening test was 8.17.

Conclusions. Copper sulphate densitometry was accurate in screening for childhood anaemia.

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Anaemia is the most common haematological disease of infancy and childhood. Iron deficiency anaemia due to inadequate intake of iron is common, especially between 9 and 24 months of age.[1] It may lead to tiredness, irritability and anorexia, as well as to dramatic manifestations such as cardiac

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failure, breath-holding spells and even stroke.[1,2] The decreased attention span and learning associated with iron deficiency may have adverse effects on cognitive and psychomotor development.[1,3] Furthermore, appropriate treatment of iron deficiency is effective and safe. It would therefore seem worth while to screen for anaemia in young children.

The clinical assessment of anaemia is subjective with wide inter-observer variability.[4] Screening requires an objective test that is simple and cheap, with reasonable accuracy. Operation without electricity or batteries is preferable, especially in developing countries.[5]

The copper sulphate test is reliable, simple and inexpensive in screening for anaemia in adult populations.[6-8] It is based on Archimedes' principle of relative densities, which states that an object will sink in a solution of lower specific gravity (SG), or float in a solution of higher SG. The major determinants of SG of blood are haemoglobin (Hb) concentration and plasma protein concentration. When a drop of blood falls into a solution of copper sulphate, a sac of copper proteinate forms on the surface of the drop, preventing a change in its SG for 5 - 10 seconds. The momentum of its fall carries the drop 1 - 2 cm below the surface. During the next 5 seconds, the drop will either rise (indicating a lower SG of the blood compared with the solution), continue to sink (indicating a blood SG higher than that of the solution), or remain stationary for a few seconds and then sink (indicating that the blood SG equals that of the solution).

Although the copper sulphate test was originally devised during World War II to determine haemoglobin concentration accurately[6,7] — using a range of solutions with different specific gravities — the test could be used to detect Hb concentrations below a specific screening level.

To our knowledge, there are no published evaluations of copper sulphate densitometry as a screening test for childhood anaemia. If accurate, copper sulphate densitometry could facilitate earlier diagnosis, investigation and treatment of anaemia in childhood. It could even be used to monitor response to treatment.

Objectives

The objective of the study was to determine the sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio of copper sulphate densitometry in screening for anaemia in young children. As a secondary objective, the prevalence and characteristics of anaemia were determined in the study population.

Methods and measurements

A cross-sectional screening study was undertaken in the outpatient department of Pretoria Academic Hospital and a local crèche ('Die Eike'). One hundred consecutive children, aged between 6 months and 6 years, were studied, after informed written consent for participation in the study had been obtained from their parents. The Research Ethics Committee of the University of Pretoria approved the study.

All children were weighed on a standardised scale in the outpatient clinic or at the crèche. The length of children below 3 years of age was measured supine on a measuring board and children older than 3 years were measured standing up. The investigators also made a clinical nutritional assessment.

Venous blood samples were collected for a full blood count. Laboratory technicians performed these tests using the ADVIA 120 Hematology System. Hb concentration was determined in this system, using a modification of the manual cyanmethaemoglobin method developed by the International Committee for Standardisation in Hematology. Plasma protein and albumin concentrations were also measured.

A medical student performed the copper sulphate tests using a drop of each child's blood sample, as described by Phillips *et al.*[6] (1946). We used a copper sulphate solution with SG 1.048 to screen for Hb concentrations below 10 g/dl, in accordance with the nomogram of Van Slyke *et al.*[7] and assuming a plasma protein concentration within the range 60 - 85 g/dl.

Data were recorded and analysed using the Epi Info and STATA statistical software packages. Anaemia was defined as a Hb concentration below 10 g/dl. The accuracy of copper sulphate densitometry was determined, using laboratory measurements of Hb as the gold standard. Sensitivity, specificity, and positive and negative predictive values with 95% confidence intervals (CIs) were calculated, as was the likelihood ratio for a copper sulphate test indicating anaemia. A receiver operating characteristic (ROC) curve was constructed for the copper sulphate densitometry test, to assess its ability to distinguish between anaemic and non-anaemic children. Similarly, ROC curves were constructed to identify a subgroup of children with a high prevalence of anaemia, based on age and nutritional status.

Results

Seventy-three children were recruited from the outpatient department and 27 from the crèche. The characteristics of the study population are summarised in Table I. Eleven per cent of the study participants were stunted (length for age < 90% of expected), while 6% were wasted (weight for height < 80% of expected).

The prevalence of anaemia (Hb < 10 g/dl) was 17% (95% CI 10.2; 25.8) in the study population, but varied between 7.4% in crèche children and 20.5% in children attending the outpatient department. These proportions were not statistically significantly different (Fisher's exact test). Twenty-five per cent of children aged 6 - 36 months were anaemic.

Table I. Characteristics of the study popolation

	Outpatient department (*N* = 73)	Créche (*N* = 27)	Total study population (*N* = 100)
Age (mo.) (mean (SD))	30.9 (17.0)	30.3 (15.9)	30.8 (16.6)
Gender			
Male (%)	38	12	50
Female (%)	35	15	50
Nutritional status (weight for age)			
Normal (%)	59	24	83
Underweight for age (%)	11	3	14
Marasmus (%)	2	0	2
Overweight for age (%)	1	0	1
Hb (g/dl)	11.18 (1.63)	12.07 (1.15)	11.42 (2.43)
MCV (fl)	77.46 (7.37)	77.61 (5.62)	77.50 (6.90)
Total serum protein (g/l)	72.06 (7.61)	65.70 (4.07)	70.34 (7.38)
Total serum albumin (g/l)	36.47 (5.36)	36.89 (3.96)	36.58 (5.00)
Number with Hb < 10 g/dl	15	2	17

Data are presented as mean (SD), or as percentage of the total study population.

The results obtained with the copper sulphate test are presented in Table II. Copper sulphate densitometry had a sensitivity of 88.2% (95% CI 62.3; 97.9), a specificity of 89.2% (95% CI 79.9; 94.6), a positive predictive value of 62.5% (95% CI 40.8; 80.5) and a negative predictive value of 97.4% (95% CI 90.0; 99.5) in screening for Hb < 10 g/dl. The likelihood ratio of a positive screening test was 8.17. A child with anaemia therefore had an 8.17 times greater probability of a positive screening test than a child without anaemia. The ROC curve constructed for the copper sulphate test — using a solution of SG 1.048 — had an area of 0.89 under the curve. This indicates good ability to discriminate between anaemic and non-anaemic children. The best trade-off between sensitivity and specificity was at a haemoglobin cut-off value of 10 g/dl (Fig. 1).

Table II. Results obtained with the copper sulphate test

	Laboratory Hb concentration		
Copper sulphate test	< 10 g/dl	≥ 10 g/dl	Total
Drop rose in solution	15	9	24
Drop hovered or sank	2	74	76
Total	17	83	100

Data are presented as numbers.

There were 2 false-negative screening tests, both with a laboratory Hb concentration of 9.6 g/dl. One of these children had an elevated total plasma protein concentration of 97 g/l, which probably increased the SG of his blood; the other child's plasma protein concentration was 70 g/dl. The Hb concentrations of the 9 children with false-positive copper

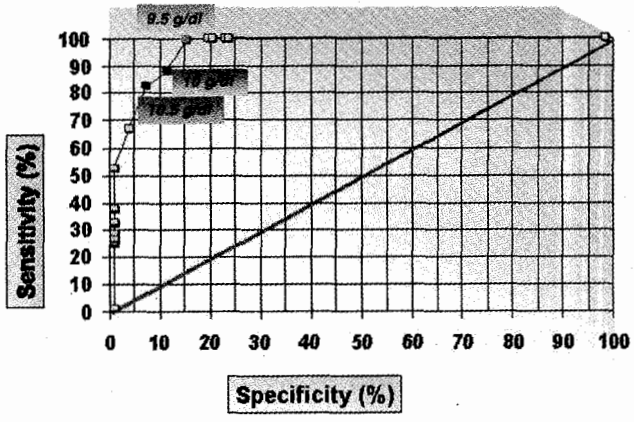

Fig. 1. Receiver operating characteristic curve: copper sulphate densitometry (SG 1.048).

sulphate tests ranged from 10.1 to 11.4 g/dl. Four of these children had Hb concentrations above 10.5 g/dl. Plasma protein concentrations of these 9 children ranged from 57 to 76 g/dl.

ROC curves were constructed to determine whether a group at high risk of anaemia could be identified on the basis of age (Fig. 2) or nutritional status (Fig. 3). If only the 67 children aged between 6 and 36 months had been screened, all 17 anaemic children would have received screening tests. The prevalence of anaemia in this age group was 25% (95% CI 15.5; 37.5).

Thirty-one per cent (95% CI 11.0; 58.7), i.e. 5, of the 16 underweight and marasmic children were anaemic. If only underweight children (weight for age less than 80% of

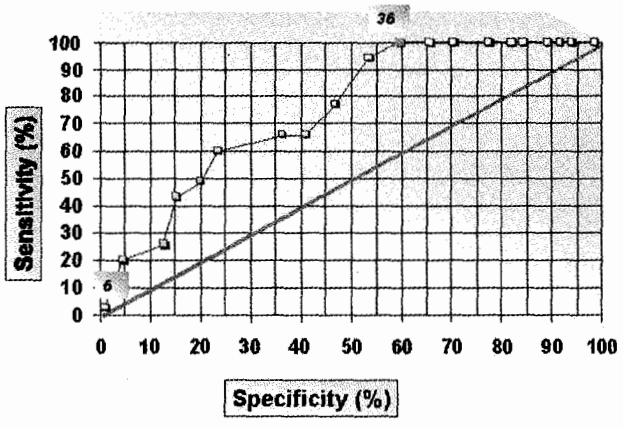

Fig. 2. Receiver operating characteristic curve: age (months).

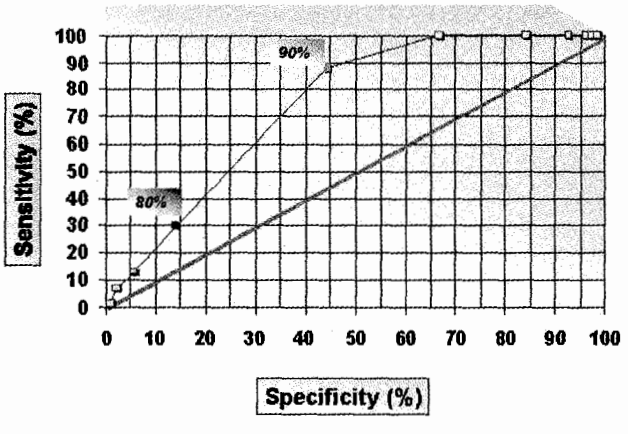

Fig. 3. Receiver operating characteristic curve: weight for age (% of median).

expected) had been screened, 71% (95% CI 44.0; 89.7) of all the anaemic children would not have been tested. Screening children between 6 and 36 months of age for anaemia therefore seems a more reasonable strategy to target a high-prevalence group and improve the positive predictive value of the copper sulphate test.

Discussion

Nutritional anaemia fulfills the conditions generally considered necessary to qualify for screening: the condition must be common, a cheap and reliable screening test must be available, and there must be a cost-effective intervention to prevent deterioration and complications. In the present study we set out to evaluate a screening test for anaemia that could be utilised in a primary care setting.

Suspicion of anaemia is usually based on the clinical sign of pallor. This is known to be a weak clinical sign with low sensitivity.[9] In a study from Lagos,[10] the sensitivity of conjunctival pallor to detect an Hb concentration below 10 g/dl was 25% in a population with a 29.9% prevalence of anaemia, the specificity was 89%, the positive predictive value was 46.9% and the negative predictive value was 75.4%. We also found the sign of pallor to have a low sensitivity and specificity. More than half of the anaemic children in the present study were considered to be 'not pale' by both senior medical students and registrars in paediatrics, yet 25% of children aged less than 36 months had a haemoglobin concentration less than 10 g/dl. Even among the crèche children without medical symptoms, 2 of 27 children were anaemic. Consequently, mild to moderate anaemia is regularly missed if the Hb is not measured.

Iron deficiency has adverse effects on cognitive function and work energy, apart from its effect on red cells and haemoglobin. The main benefit of early diagnosis lies in the potential for giving appropriate dietary advice and iron supplementation. As iron deficiency is so common, it is acceptable practice to provide short-term empiric iron therapy to young children with moderate, uncomplicated anaemia. Those not responding to this empiric therapy within a short period of time require investigation.

Screening children for anaemia by means of laboratory Hb determination would entail considerable cost. With a bedside haemoglobinometer, the patient's specific haemoglobin value is known within minutes, provided the test is performed accurately.[11] An initial capital outlay is required, however, and there are ongoing costs for haemolysing sticks and batteries. The frustrations of unworkable or incomplete equipment result in the sending of blood samples to the laboratory.

The use of copper sulphate densitometry as a screening test would be much cheaper. At present prices, the cost of one screening test would be 8 cents if 50 tests were done per 100 ml solution, as suggested by Phillips *et al.*[6] In our study, we found that it became difficult to interpret the tests (due to murkiness) after about 20 drops of blood in 100 ml solution. Replacement of 100 ml of copper sulphate solution after every 20 tests would increase the cost to 19 cents per test. The cost of screening for anaemia using copper sulphate densitometry is then about 2% of the cost of laboratory haemoglobin determination. After initial instruction, the medical students found the test easy to perform. The test result was accurate, simple to interpret and immediately available.

Currently a fresh 100 ml bottle of copper sulphate would cost in the region of R3.89 daily. A single blood drop into the bottle would rapidly and effectively identify those children requiring more careful clinical evaluation. No judgement decisions are necessary on the level of Hb obtained. The SG is set at the level at which action is required: either treatment or referral. In the present study, we chose the solution SG to correspond with a Hb level of 10 g/dl, but any other level

could be chosen to link to action policy decisions. In the Integrated Management of Childhood Illness (IMCI) programme, such a screening test would also remind the health provider to prescribe an iron tonic and to emphasise the importance of a balanced diet.

A potential disadvantage of copper sulphate densitometry lies in the gradual change of the SG of the copper sulphate solution with repeated blood drops. A fresh 100 ml solution must be available after every 20 tests. The logistics of a steady supply of copper sulphate solution must therefore be worked out for each testing site.

RECOMMENDATION

We recommend that copper sulphate densitometry screening for anaemia be incorporated in the IMCI programme at primary care level. Any child under the age of 36 months attending for incidental health care should be screened. Children who screen positive should receive a month's treatment with iron, and then return for a further screen. If the result is still positive the child should be referred for evaluation of non-responding anaemia. Children attending for routine well-baby care and immunisation at 6 and 9 months of age could similarly be screened.

We would like to thank the paediatric student elective group of November 2000 for their enthusiastic participation in making this study a success.

References

1. Schwartz E. Iron deficiency anemia. In: Behrman RE, Kliegman RM, Jenson HB, eds. *Nelson Textbook of Paediatrics*. 16th ed. Philadelphia: WB Saunders, 2000: 1469-1471.
2. Swann IL, Kendra JR. Severe iron deficiency anaemia and stroke. *Clin Lab Haematol* 2000; **22:** 221-213.
3. Sherriff A, Emond A, Bell JC, Golding J. ALSPAC Study Team. Should infants be screened for anaemia? A prospective study investigating the relation between haemoglobin at 8, 12, and 18 months and development at 18 months. *Arch Dis Child* 2001; **84:** 480-485.
4. Gjorup T, Bugge TM, Hendricksen C, Jensen AM. A critical evaluation of the clinical diagnosis of anemia. *Am J Epidemiol* 1986; **124:** 657-665.
5. Stone JE, Simmons WK, Jutsum PJ, Gurney JM. An evaluation of methods of screening for anaemia. *Bull World Health Organ* 1984; **62:** 115-120.
6. Phillips RA, Van Slyke DD, Hamilton PB, *et al*. Measurement of specific gravities for whole blood and plasma by standard copper sulfate solutions. *J Biol Chem* 1950; **183:** 305-330.
7. Van Slyke DD, Phillips RA, Dole VP, *et al*. Calculation of hemoglobin from blood specific gravities. *J Biol Chem* 1950; **183:** 349-360.
8. Pistorius LR, Funk M, Pattinson RC, Howarth GR. Screening for anaemia in pregnancy with copper sulfate densitometry. *Int J Gynecol Obstet* 1996; **52:** 33-36.
9. Kalter HD, Burnham G, Kolstad PR, *et al*. Evaluation of clinical signs to diagnose anaemia in Uganda and Bangladesh, in areas with and without malaria. *Bull World Health Organ* 1997; **75:** suppl 1, 103-111.
10. Ekunwe EO. Predictive value of conjunctival pallor in the diagnosis of anaemia. *West Afr J Med* 1997; **16:** 246-250.
11. Linegar AG, Knottenbelt JD, Wormald PJ. Accuracy of a portable haemoglobinometer in clinical practice. *S Afr Med J* 1991; **79:** 547-548.

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SACROCOLPOPEXY — A REPORT ON 262 CONSECUTIVE OPERATIONS

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Objectives. This report analyses the outcome and complications of 262 consecutive sacrocolpopexy procedures for the repair of vaginal vault prolapse and enterocele.

Methods. From March 1994 to February 2001, 262 patients underwent surgical repair using a standardised retroperitoneal technique. Initially dura mater strips were used and from the 19th patient onwards, Gore-tex soft tissue patch was used to suspend the vaginal apex to the anterior sacral ligament. Halban-type occluding sutures were placed in the pouch of Douglas. All patients were followed up and the minimum duration of follow-up was 16 months.

Results. Vaginal vault prolapse was successfully managed in 259 of 262 patients giving a success rate of 98.8%. In addition, 4 patients had a repeat enterocele that required surgical repair. The overall surgical complication rate was low. Erosion of the patch through the vaginal vault occurred in 10 patients, necessitating removal of the patch. Prolapse did not recur in any of these patients.

Conclusion. Abdominal sacrocolpopexy is a very successful and safe surgical management of vaginal vault prolapse.

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Post-hysterectomy prolapse of the vaginal vault is an uncommon late effect of hysterectomy, with reported incidence rates of 0.1 - 1%.[1] The pathophysiology is a failure of the support mechanisms of the vagina due to factors including weakness of collagen tissue, pelvic floor damage associated with pregnancy and childbirth, and possibly the hysterectomy itself as this leads to transection of the ligamentous supports of the cervix. Patients present with pelvic discomfort, urinary or colorectal urgency, difficulty in voiding which may often require manual support of the prolapse to allow the act of voiding, and overflow urinary incontinence.[1,2] Vaginal vault prolapse inevitably presents as an enterocele.

The surgical management of severe partial or total prolapse of the vaginal vault remains a challenging prospect.[1-3] Because

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