Published in final edited form as:

Ann Trop Paediatr. 2011 ; 31(1): 67–74. doi:10.1179/1465328110Y.0000000006.

Myocardial ischaemia in sickle cell anaemia: evaluation using a new scoring system

F. BODE-THOMAS, H. I. HYACINTH[‡], O. OGUNKUNLE[★], and A. OMOTOSO[†]

Department of Paediatrics, University of Jos, Jos

[★] Department of Paediatrics, University College Hospital, Ibadan

[†] Department of Medicine, College of Health Sciences, University of Ilorin, Ilorin, Nigeria

[‡] Department of Microbiology, Biochemistry & Immunology, Morehouse School of Medicine, Atlanta, Georgia, USA

Abstract

Background—Sickle cell anaemia (SCA) is associated with recurrent multi-organ ischaemia and infarction. Myocardial ischaemia (MI) and infarction are increasingly recognised as features of SCA. The prevalence and severity of MI in children with SCA is not known.

Aim—To evaluate the usefulness of a new scoring system based on the standard surface electrocardiogram (ECG) in determining the prevalence and severity of MI in children with SCA.

Method—MI prevalence and scores derived from standard surface ECGs of 35 children with SCA aged 3–18 years who presented consecutively during 38 episodes of vaso-occlusive crisis (VOC) were compared with those of 40 age- and sex-matched SCA patients in the steady state and 40 anaemic non-SCA patients. In SCA subjects with VOC, ECG was repeated approximately 1 week and 4–8 weeks post crisis and the respective MI scores were compared with their intra-crisis ECG and those of the two other groups.

Results—Mean (SD) MI scores were significantly higher during vaso-occlusive crises [1.82 (0.20)] compared with the steady state [1.15 (0.15)] and non-SCA anaemic controls [1.13 (0.21)], $p=0.017$. SCA patients in crisis were 5.5 (1.20–13.99) times more likely to have MI compared with non-SCA anaemic controls ($p=0.025$). They were also 3.66 (1.05–12.74, $p=0.042$) and 7.58 (1.31–43.92, $p=0.024$) times more likely to have mild and significant MI, respectively. MI scores derived from the post-crisis ECGs were similar to those of steady-state SCA patients.

Conclusion—ECG changes consistent with MI are common in children with SCA, especially during vaso-occlusive crises. Our proposed MI scoring system could be a useful screening tool for early detection of significant MI during crises, facilitating early institution of intervention. Further studies are needed to determine the specificity of the observed changes and to validate the proposed screening tool.

Introduction

Sickle cell anaemia (SCA) is characterised by repeated sickling of erythrocytes under hypoxic conditions, leading to recurrent occlusion of small blood vessels and vascular injury which may lead to further thrombosis, haemolysis, chronic anaemia and chronic sub-clinical inflammation. These often result in chronic and acute ischaemic complications which may

involve any organ or tissue.¹ Myocardial ischaemia (MI) is increasingly recognised as a feature of sickle cell anaemia (SCA) in both children and adults.^{2,3} Myocardial infarction has also been reported in adolescents and adults with SCA.^{4–8} Until recently, the heart was not considered an organ of high risk in children.³ This is perhaps because MI and infarction are often clinically overshadowed by more dramatic presentations of vaso-occlusion such as musculo-skeletal pains.⁷ However, 10–30% of adults suffer from cardiac impairment as a result of SCA, mostly left ventricular dysfunction and heart failure.⁹ It is postulated that chronic steady-state functional impairment may be related to chronic recurrent micro-injury, the effects of which may be additive.¹⁰ Such recurrent injuries might have begun years before, possibly in childhood. This view is supported by several pathological studies which have demonstrated degenerative myocardial changes, fibrosis, healed infarcts and clogging of intramural (micro) coronary vessels by aggregates of sickle cells.^{6,11–14} Sudden death in these patients may result from infarction or the arrhythmogenic effects of severe ischaemia.¹⁰

The prevalence of MI and infarction in patients with SCA especially while in crisis is still unclear. De Montalembert *et al.* demonstrated myocardial perfusion defects in 14 of 22 SCA children with chest pain or ECG/echocardiographic findings suggestive of MI.³ Norris *et al.* found evidence of MI in 80% of SCA patients in crisis based on abnormal ECG criteria and in 84% based on abnormal cardiac enzyme levels, and myocardial perfusion defects were detected in 68% by Thallium-201 scanning.² Both studies focused on a subset of patients considered likely to have MI. It is useful to screen for the presence of MI in SCA patients not necessarily considered to be at high risk since significant MI may be silent or overshadowed by musculo-skeletal pain. Early detection and the institution of appropriate therapy could be life-saving. Recognised electrocardiographic (ECG) features of MI including arrhythmias, conduction defects and re-polarisation abnormalities such as ST-T wave changes and prolonged QTc have all been reported in SCA patients.^{13–18} Based on these features, we propose a new MI scoring system derived from the standard surface ECG, which may be useful in the early detection of significant MI in SCA patients, before the clinical manifestations become evident and before more sophisticated investigations can be undertaken. For practitioners in resource-poor settings this will not only represent tremendous savings in cost but in many instances may be the only tool available.

This study investigates the prevalence and severity of MI in a group of patients with SCA, using a simple ECG-based scoring system.

Patients and Methods

Thirty-five SCA patients who presented consecutively within a 1-year period during 38 episodes of vaso-occlusive crisis (VOC) were recruited into study group A whose anthropometric data, haematocrits and standard surface ECG were recorded at presentation. Three group A patients each presented during two different VOC episodes, each of which was considered to be a separate event. Thirty-eight group A VOC subjects were matched for age and sex with 40 steady-state SCA patients attending out-patients (group B) and 40 anaemic children (haematocrit <30%) shown by haemoglobin electrophoresis to be free of SCA or any other haemoglobinopathy (group C). All study subjects were black African children. Group B subjects (steady-state SCA patients) were SCA patients being followed up in our regular SCA clinics who had not been enrolled previously into study group A and who had been free of crisis or other acute illness for at least 4 weeks before the date of their ECG. Subjects with respiratory illness, heart disease, elevated blood pressure, electrolyte derangement, renal failure, diarrhoeal disease, under-nutrition or receiving digitalis or other anti-arrhythmic drugs were excluded. All subjects received the standard therapy appropriate at the time of the study and for SCA patients (groups A and B) this included routine folic

acid and proguanil. No patient was on a regular transfusion programme and none received hydroxyurea as these are not part of our routine practice. Group A patients were hydrated and given analgesics, antimalarials and/or antibiotics as indicated, while group C patients mostly received folic acid, anti-malarials and antibiotics, as indicated. A few patients were transfused after their ECG had been recorded (while cross-matching blood). Approval for the study was obtained from the hospital's ethics committee and informed consent was obtained from the patients' parent(s) and in addition verbal assent was obtained from the older children.

Group A subjects had their haematocrits and ECGs repeated at two other visits approximately 1 week (6–9 days) and 4–8 weeks after crisis, respectively. All ECGs were recorded using a portable electronic electrocardiograph (model 9953, Seward, UK), analysed in the standard manner¹⁶ and scored by the same investigator according to the criteria outlined in Table 1. The maximum score obtainable by any patient was 10 and the minimum zero. If present, MI was further graded as mild or significant, corresponding with MI scores of 1–2, and >3, respectively. MI was considered to be present if the Q-wave was abnormal in any lead (duration >0.04 seconds with or without notching), if the ST-segment was elevated beyond 2 mm or if the corrected QT interval (QTc) exceeded 0.440 seconds with accompanying Q-wave abnormalities.¹⁶ For the purposes of this study, MI was considered to be a transient state that could subside when the offending cause such as anaemia or VOC is removed,¹⁹ and we therefore included SCA patients presenting in subsequent VOC episodes as each VOC episode was treated as an isolated event.

Statistical analysis

Data were analysed using PASW statistics (SPSS) 18.0 from IBM and Microsoft Excel® Build 6514 with sp2. MI scores were compared between groups and within group A (intra-with post-crisis ECGs) using ANOVA and the *t*-test, as necessary. Logistic regression was used to calculate values for odds ratios and McNemar's test was used to compare differences in frequency of MI severity. The relationship between MI scores and anaemia was analysed using Pearson's correlation co-efficient. A *p*-value of <0.05 was considered statistically significant.

Results

Overall, 118 subjects were enrolled, 72 (62.6%) of whom were male. The three groups did not differ significantly in mean age, gender or haematocrit (Table 2). In group C subjects, the reasons for anaemia were malaria in 60%, recuperation from other infections in 25% and from burns in 7.5%. Others were considered to be primarily nutritional (5%) while the remaining 5% were associated with other (non-infective) pathologies such as nephrotic syndrome and acute myeloblastic leukaemia.

ECG findings

Patients in groups A (SCA in vaso-occlusive crisis) and C (non-SCA anaemic children) had significantly faster mean heart rates (in keeping with their acute clinical conditions) than subjects in group B (steady-state SCA), $p=0.002$ (Table 3). SCA patients (groups A and B) were significantly more likely to have abnormal rhythms, prolonged QTc intervals and T-wave abnormalities than the non-SCA subjects (group C), while those in vaso-occlusive crisis (group A) were significantly more likely to have ST-depression and of greater severity than both steady-state SCA and non-SCA anaemic subjects, $p<0.001$ (Table 3). Overall, patients in group A were more likely to have abnormal ECG findings (and slightly more severe forms, suggestive of MI) than those in groups B and C. Although group C patients

had a higher prevalence (10%) of ST elevation compared with groups A (2.6%) and B (0%), this was not statistically significant. No patients had ECG evidence of myocardial infarction.

Myocardial ischaemia (MI) scores

Group A subjects had the highest prevalence of MI (89.5%), followed by groups B (72.5%) and C (67.5%) ($p=0.059$). Their respective odds of having MI were 8.5, 2.64 and 2.08. Comparison of odds ratios of having MI demonstrated that group A subjects were 5.5 times more likely (1.20–13.99, $p=0.025$) to have any form of MI than group C, and 3 times more likely (0.81–11.07, $p=0.1$) than those in group B, while the latter was only 1.5 (0.53–4.22, $p=0.626$) times more likely to have MI than group C (Table 4).

The majority of subjects with MI in all three groups, however, had mild MI with the SCA patients in crisis having a relatively higher proportion of significant MI (Table 3). Nevertheless, group A was significantly more likely to have both mild and significant MI compared with group C [odds ratios 3.66 (1.05–12.74, $p=0.042$) and 7.58 (1.31–43.92, $p=0.024$), respectively]. Group B (steady-state SCA) did not, however, differ significantly from group C (non-SCA) in this respect [odds ratios for mild and significant MI were 1.18 (0.44–3.16, $p=0.111$) and 1.97 (0.38–10.17, $p=0.418$)] (Table 4).

Group A also had significantly higher mean MI scores ($p=0.017$) than either of the other two groups (Table 3), while the regression model showed that prolonged QTc and T-wave abnormalities were the most important indicators of MI ($p=0.001$ and 0.048, respectively), with QTc prolongation being the most important ($p=0.014$).

MI and anaemia

Group C subjects showed statistically significant negative correlation between the presence of ST elevation ($r = -0.35$, $p=0.026$), ST depression ($r = -0.38$, $p=0.015$) and haematocrit. There was no such relationship in groups A and B.

Post-crisis ECGs

Post-crisis ECGs were available for 21 and nine group A subjects at 1 week and at 4–8 weeks post-crisis, respectively. There was a significant decrease in the mean MI score from 1.86 (0.20) during crisis to 1.10 (0.15) at about 1 week and 1.00 (0.30) at 4–8 weeks post crisis, respectively ($p=0.005$). However, the mean MI scores derived from the two post-crisis ECGs did not differ significantly from each other or from those of the steady-state SCA (group B) and anaemic non-SCA (group C) patients.

Discussion

Our MI scoring system demonstrates that SCA patients in vaso-occlusive crises have significantly higher mean MI scores than their counterparts in the steady state and the non-SCA anaemic subjects. They also have a significantly higher prevalence of MI (both mild and significant) than the anaemic non-SCA subjects. Although they had a higher prevalence of MI than their steady-state counterparts, the difference was not statistically significant. Since the groups did not differ with respect to the severity of their anaemia (mean haematocrit), it is possible that the vaso-occlusive state may be responsible for these differences. Other possible explanations for the repolarisation changes include autonomic imbalance and vaso-spasm possibly secondary to catecholamine surges that might be associated with the crisis state. Although we were careful to exclude patients who might have electrolyte imbalances, many of them received antibiotics and antimalarials. We have, however, shown in a previous report that the presence of arrhythmias in these patients was not related to the use of any of these drugs.²⁰

Although Leung *et al.*¹⁹ limited their definition of MI to ST-segment changes, we have broadened ours to include other recognised ECG features such as abnormal rhythm, prolonged QTc, T-wave abnormalities and prolonged PR.¹⁶ Of the latter, the first three were similar in prevalence in both SCA patients in crisis and their counterparts in the steady state, which may be explainable on the basis of ischaemia from chronic anaemia. Cardiac arrhythmias, mostly abnormalities of atrial rhythm, are more common in children with SCA than in anaemic non-SCA controls.¹⁷ Also, individual SCA patients tend to exhibit great variability in their cardiac rhythm.²⁰ Furthermore, children with SCA have been reported to have significantly longer QTc intervals and a higher prevalence of prolonged QTc than anaemic controls.¹⁸ Similar findings have been reported in adult SCA patients,²¹ while other researchers have reported a high prevalence of prolonged QTc intervals (8%) in children with SCA.²²

Although T-wave and ST-segment abnormalities have long been associated with SCA and other chronic anaemias,^{14,15} our data show that ST depression in particular appears to be associated with the crisis state, suggesting an additional strain on the myocardium during this period. Conversely, the non-SCA subjects were slightly more prone to ST elevation. This would seem to suggest that chronic anaemia may be more likely to be associated with ST depression and T-wave abnormalities while anaemia of more acute onset might be associated with ST elevation. This suggestion is, however, at variance with the observation of ST depression in healthy adults undergoing haemodilution, thus calling for further studies of anaemic adults and children in this regard. The absence of any correlation between severity of anaemia and ECG abnormalities among our SCA patients may point to their possible adaptation to the chronic anaemic state. This adaptation, which is not present in the anaemic non-SCA patients, might explain the statistically significant negative correlation between anaemia and MI in this group of patients.

Management of the SCA patients in VOC was not specifically cardiac-directed, but rather aimed to relieve pain, to hydrate the children and to treating underlying infection, if present. There was, nevertheless, a significant decrease in their mean MI scores by 1 week and a further decrease by 4–8 weeks post crisis, suggesting resolution of factors responsible for their higher MI scores during the crisis episode. The absence of a statistically significant difference between either of the post-crisis scores and that of patients who remained in the steady state, suggests a baseline chronic ischaemia that perhaps worsens intermittently during vaso-occlusive crises. Although none of them had clinically or ECG-evident myocardial infarction, infarction of microscopic portions of the myocardium cannot be entirely excluded and might account for the patchy and microscopic fibrotic changes described by some authors.^{14,15} Clinically evident myocardial infarction has so far been reported only in adolescents and adults, but not in younger children. Some studies have reported the occurrence of silent cerebral infarcts.^{23,24} As the same process conceivably could occur in other organs including the myocardium, there is a need for further investigation of the occurrence of overt and covert myocardial infarction in both adults and children with SCA. In the long term, recurrent episodes of ischaemia might have detrimental effects on myocardial performance, especially as that organ also has to cope with the stress of chronic anaemia.

In the short-term, patchy micro-vascular occlusion will lead to areas of hypo-perfusion, myocardial injury from ischaemia with or without infarction, and impaired myocardial function, as demonstrated by several authors.^{2,3} De Montalembert *et al.* reported an improvement in myocardial perfusion among their patients with evidence of myocardial ischaemia after the administration of hydroxyurea.³ Our data show that the findings can reverse spontaneously. However, their patients may have had more severe ischaemia than ours since they purposely selected symptomatic patients or those with echocardiographic

abnormalities. Nevertheless, caution should be exercised when administering hydroxyurea to SCA patients who already have features of MI.²⁵ Some workers have advocated the use of blood transfusion in improving cerebral perfusion in SCA patients,^{26,27} while there have been individual reports of reversal of cardiac symptoms after blood transfusion.⁴ We have not evaluated this or any other therapeutic modalities for MI but have simply tried to screen for its presence and possible severity.

This study suggests that MI may be quite common in children with SCA and that it is probably worsened during VOC. We propose a simple ECG-based tool that may be useful at the bedside to screen for the presence of significant MI. Since severe ischaemia can predispose to sudden death during sickle cell crises, its early detection may be life-saving. The availability of a simple screening tool becomes invaluable, especially in resource-poor settings such as ours. Further studies validating the usefulness of this ECG-based screening tool in SCA and other patients at risk of MI are, however, necessary.

References

1. Okpala I. Leukocyte adhesion and the pathophysiology of sickle cell disease. *Curr Opin Hematol* 2006;13:40–4.
2. Norris S, Johnson CS, Haywood LJ. Sickle cell anemia: does myocardial ischaemia occur during crisis? *J Natl Med Assoc* 1991;83:209–13. [PubMed: 2038080]
3. de Montalembert M, Maunoury C, Acar P, Brousse V, Sidi D, Lenoir G. Myocardial ischaemia in children with sickle cell disease. *Arch Dis Child* 2004;89:359–62. [PubMed: 15033848]
4. Saad STO, Arruda VR, Junqueira OOMD, Schelini FA, Coelho OB. Acute myocardial infarction in sickle cell anaemia associated with severe hypoxia. *Postgrad Med J* 1990;66:1068–70. [PubMed: 2084657]
5. Woodruff AW. Sickle cell anaemia with complicating coronary infarction. *Proc R Soc Med* 1970;63:48. [PubMed: 5417773]
6. Martin CR, Johnson CS, Cobb C, Tatter D, Haywood LJ. Myocardial infarction in sickle cell disease. *J Natl Med Assoc* 1996;88:428–32. [PubMed: 8764524]
7. Mansi IA, Rosner F. Myocardial infarction in sickle cell disease. *J Natl Med Assoc* 2002;94:448–52. [PubMed: 12078925]
8. Deyman AJ, Goertz KK. Myocardial infarction and transient ventricular dysfunction in an adolescent with sickle cell disease. *Pediatrics* 2003;111:e183–7. [PubMed: 12563093]
9. Covitz, W. Cardiac disease. In: Embury, SH.; Hebbel, RP.; Mohandas, N.; Steinberg, MH., editors. *Sickle Cell Disease: Basic Principles and Clinical Practice*. New York, NY: Raven Press; 1994.
10. Haywood LJ. Cardiovascular function and dysfunction in sickle cell anaemia. *J Natl Med Assoc* 2009;101:24–30. [PubMed: 19245069]
11. Gerry J, Bulkley BH, Hutchins GM. Clinicopathologic analysis of cardiac dysfunction in 52 patients with sickle cell anemia. *Am J Cardiol* 1978;42:211–16. [PubMed: 150786]
12. Lester LA, Sodt PC, Hutcheon N, Arcilla RA. Cardiac abnormalities in children with sickle cell anemia. *Chest* 1990;98:1169–74. [PubMed: 2146092]
13. Oliveira E, Gómez-Patino N. Falcemic cardiopathy: report of a case. *Am J Cardiol* 1963;11:686–8.
14. Uzsoy NK. Cardiovascular findings in patients with sickle cell anemia. *Am J Cardiol* 1964;13:320–8. [PubMed: 14128641]
15. Reimer, KA.; Jennings, RB. Myocardial ischemia, hypoxia and infarction. In: Fozzard, HA., editor. *The Heart and Cardiovascular System*. New York, NY: Raven Press; 1986.
16. Park, MK.; Guntheroth, WG. Basic measurements. In: Park, MK.; Guntheroth, WG., editors. *How to Read Pediatric ECGs*. St Louis, MO: Mosby Year Book; 1992.
17. Bode-Thomas F, Ogunkunle OO, Omotoso ABO. Cardiac arrhythmias in children with sickle cell anaemia. *Nig J Paediatr* 2003;30:13–17.
18. Bode-Thomas F, Ogunkunle OO, Omotoso ABO. The QT interval in Nigerian children with sickle cell anaemia. *Trop Cardiol* 2003;113:9–12.

19. Leung JM, Weiskopf RB, Feiner J, et al. Electrocardiographic ST-segment changes during acute, severe isovolemic hemodilution in humans. *Anesthesiology* 2000;93:1004–10. [PubMed: 11020755]
20. Bode-Thomas F, Ogunkunle OO, Omotoso ABO. Atrial arrhythmias and the QT interval in Nigerian children with sickle cell anaemia. *Nig J Cardiol* 2005;2:25–32.
21. Adebayo RA, Balogun MO, Akinola NO, Akintomide AO. Cardiovascular changes in sickle cell anaemia. *Nig J Med* 2002;11:145–52.
22. Mueller BU, Martin KJ, Dreyer W, Bezold LI, Mahoney DH. Prolonged QT interval in pediatric sickle cell disease. *Pediatr Blood Cancer* 2006;47:831–3. [PubMed: 16078213]
23. White DAP, Moinuddin AM, McKinstry RCM, Noetzel MM, Armstrong MB, DeBaun MM. Cognitive screening for silent cerebral infarction in children with sickle cell disease. *J Pediatr Hematol Oncol* 2006;28:166–9. [PubMed: 16679942]
24. Yalçın H, Melek I, Okuyucu E, et al. Sickle cell disease with regional silent cerebral infarction detected by SPECT. *Clin Nucl Med* 2007;32:842–3. [PubMed: 18075416]
25. Fattori A, de Souza RA, Saad ST, Costa FF. Acute myocardial infarction in sickle cell disease: a possible complication of hydroxyurea treatment. *Hematol J* 2005;5:589–90. [PubMed: 15692605]
26. Enniful-Eghan H, Moore RH, Ichord R, Smith-Whitley K, Kwiatkowski JL. Transcranial Doppler ultrasonography and prophylactic transfusion program is effective in preventing overt stroke in children with sickle cell disease. *J Pediatr* 2010;157:479–84. [PubMed: 20434165]
27. Lee MT, Piomelli S, Granger S, et al. Stroke prevention trial in sickle cell anemia (STOP): extended follow-up and final results. *Blood* 2006;108:847–52. [PubMed: 16861341]

TABLE 1

Criteria for derivation of myocardial ischaemia (MI) scores from standard 12-lead electrocardiograms.

Parameter	Score
Any non-sinus rhythm	1
Conduction disturbances *	1
QTc >0.440 seconds	1
QRS-T angle >90 degrees	1
ST elevation or depression >1 mm in 1 or 2 leads	1
ST elevation or depression >1 mm in 3 or 4 leads	2
ST elevation or depression >1 mm in ≥5 leads	3
Flat, diphasic or inverted T-waves in 1 or 2 leads	1
Flat, diphasic or inverted T-waves in 3 or 4 leads	2
Flat, diphasic or inverted T-waves in ≥5 leads	3
Maximum score obtainable	10

* PR interval >0.16 s, QRS duration ≥0.1 s, sinus pauses with or without escape beats or rhythms.

TABLE 2

Some characteristics of the study participants.

Characteristics	Group A	Group B	Group C
Male [*]	23 (65.7%)	23 (57.5%)	26 (65.0%)
Age (y) [†]	9.93 (4.04)	10.27 (4.31)	8.75 (3.81)
Haematocrit [†]	22.39 (5.89)	22.70 (4.05)	22.58 (5.60)

^{*} Frequency (relative frequency);

[†] mean (SD); all variables statistically non-significant.

TABLE 3

Comparison of selected ECG parameters between study groups A, B and C.

ECG parameter	Group A (n=38)	Group B (n=40)	Group C (n=40)	p-value
Heart rate, mean (SD)	116 (21)	100 (19)	118 (28)	0.002
Abnormal rhythm	5 (13.2)	4 (10.0)	–	0.072
Prolonged PR	4 (10.5)	3 (7.5)	8 (20.0)	0.071
Prolonged QTc	5 (13.2)	7 (17.5)	2 (5.0)	0.001
ST elevation	1 (2.6)	–	4 (10)	0.071
1–2 leads	–	–	3 (7.5)	
≥3 leads	1 (2.6)	–	1 (2.5)	
ST depression	20 (52.6)	6 (15.0)	10 (25.0)	<0.001
1–2 leads	13 (34.2)	6 (15.0)	8 (20.0)	
≥3 leads	7 (18.3)	–	2 (5.0)	
T-wave abnormality	23 (60.5)	25 (62.5)	14 (35.0)	0.016
1–2 leads	22 (57.9)	23 (57.5)	13 (32.5)	
≥3 leads	1 (2.6)	2 (5.0)	1 (2.5)	
Presence of MI	34 (89.5)	29 (72.5)	27 (67.5)	0.059
Mild	27 (71.1)	24 (60.0)	24 (60.0)	0.042
Significant	7 (18.4)	5 (12.5)	3 (7.5)	<0.001
Mean MI score (SEM)	1.82 (0.20)	1.15 (0.15)	1.13 (0.21)	0.017

Group A, SCA in crisis; Group B, SCA in steady state; Group C, non-SCA anaemic patients; MI, myocardial ischaemia; SEM, standard error of the mean.

TABLE 4

Comparison of odds for myocardial ischaemia between groups.

Groups compared	Odds ratio	95% confidence interval	p-value
MI (all grades)			
Crisis vs steady state	3.0	0.81–11.07	0.1
Crisis vs non-SCA	5.5	1.20–13.99	0.025
Steady state vs non-SCA	1.5	0.53–4.22	0.626
MI (mild)			
Crisis vs steady state	1.6	0.87–3.07	0.102
Crisis vs non-SCA	3.7	1.05–12.74	0.042
Steady state vs non-SCA	1.2	0.44–3.16	0.111
MI (significant)			
Crisis vs steady state	1.6	0.69–3.81	0.235
Crisis vs non-SCA	7.6	1.31–43.92	0.024
Steady state vs non-SCA	2.0	0.38–10.17	0.418