Clinical Topics

Use of low-dose insulin infusions in diabetics after myocardial infarction

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Abstract

Myocardial infarction in diabetics is often accompanied by poor diabetic control. An assessment of a low-dose insulin infusion regimen in 26 diabetic patients after myocardial infarction found this system to be simple, effective, and safe.

Introduction

The metabolic response to myocardial infarction¹ exacerbates the abnormal metabolism of patients with diabetes mellitus resulting in difficulties in diabetic control. Low-dose insulin infusion regimens were initially developed for the management of diabetic ketoacidosis² and were subsequently extended to the control of labour³ and surgery.⁴ We report the use of such a regimen as a simple, safe, and effective method of controlling the metabolic changes in diabetics who sustain myocardial infarction.

Methods

PATIENTS

We studied 26 patients whose mean age was 63 years (range 44-80): 22 were men; five were insulin-dependent, 18 took oral hypoglycaemics, and three were treated by diet alone. Twenty of these patients had myocardial infarction (defined as having two of the following criteria: prolonged central chest pain; a transient rise of aspartate aminotransferase to greater than twice normal; or new Q waves in the 12-lead electrocardiograph (ECG)); and six patients had angina (defined as cardiac ischaemic pain accompanied by ECG or enzyme changes that did not reach levels diagnostic of infarction). The median time from the onset of infarction to the beginning of the infusion of insulin was five hours (range 1-48 hours).

ANALYSIS

Blood was withdrawn for analysis through an indwelling catheter at the following times: hourly to four hours, four-hourly to 24 hours after admission, and before meals (at 0800, 1200, and 1530) on the second, third, and fourth days. Blood glucose concentration was measured by a glucose oxidase method (Reflotest, Boehringer) and a reflectance meter (Reflomat, Clinicon). The accuracy of the reflectance meter and that of the analysts was checked regularly by

analysing duplicate samples of blood, one being assayed by our method and the other by a colorimetric glucose assay by the department of clinical chemistry.

Insulin was infused by infusion pump using 48 ml aliquots of a solution of 42 ml normal saline, 6 ml of 3.5% polygeline (Haemacel, Hoechst), and 16 units Actrapid insulin. The rate of infusion was determined by the blood glucose concentration, and the protocol we adopted was as follows: no insulin if blood glucose was less than 4 mmol/l, one unit of insulin an hour if blood glucose was between 4 and 8 mmol/l, two units an hour if blood glucose was between 8 and 12 mmol/l, and four units an hour if the blood glucose exceeded 12 mmol/l. Blood sampling, measurement of glucose, and adjustment of insulin infusion rates were performed by the nursing staff, all of whom had had a course of training in the use of the reflectance meter.

As is the custom in managing all diabetic inpatients in our hospital, their normal diet was reduced by 20 g of carbohydrate to compensate for their reduced energy requirement. Patients were offered meals at the normal times from the time of admission onwards. On the fourth day they were transferred to a twice-daily regimen of subcutaneous insulin unless there were strong contraindications. All patients were reviewed at one month, when the use of insulin was reconsidered.

Results

Six of the 26 patients admitted to the trial died in hospital, the median date of death being four days after infarction (range 2-50 days). All six patients died as a result of severe heart failure due to large myocardial infarctions.

Figure 1 shows the response to the infusion of insulin. The initial blood glucose was 15.1 ± 11.0 mmol/l (mean $\pm$ 1 SD) and this fell to 7.6 ± 4.0 mmol/l over 12 hours; the necessary insulin infusion rates are shown in the same figure and fell from 3.4 ± 1.7 U/h on admission to 2.1 ± 1.2 U/h at 12 hours.

Ten patients had glucose values greater than 15 mmol/l on admission (fig 2). In these patients the blood glucose concentration fell steadily from a mean of 24.6 mmol/l ± 12.9 mmol/l to a mean value of 9.4 ± 4.4 mmol/l at 12 hours. In all 10 patients the glucose fell steadily, although in three patients we elected to use higher infusion rates (8 to 10 U/h) for the first three hours.

Sixteen patients had blood glucose concentrations below 15 mmol/l on admission (fig 3). Except for one patient all subsequent blood values remained below 15 mmol/l over the first 24 hours. The one exception showed a transient rise in blood glucose value before falling to below the admission value at four hours.

We maintained the infusion for the following three days and as shown in the table blood glucose values were maintained between 5 and 10 mmol/l, using insulin infusion rates from 1.8 to 2.5 U/h.

Symptomatic hypoglycaemia occurred on single occasions in four patients. In each case symptoms were mild and were not accompanied by angina, arrhythmias, or ECG changes. During the first four days a total of 423 glucose estimations were made, of which 20 (4.7%) were below 3.0 mmol/l.

Thrombophlebitis at the infusion site occurred in 16 patients. Initially we used pure Haemacel as the carrier, and this resulted in inflammation in eight out of nine patients. Dilution of the Haemacel

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FIG 1—Mean response of all 26 patients to infusion of insulin. Dots represent mean blood glucose, histogram represents insulin infusion, and bars are one standard deviation.

FIG 2—Mean response of 10 patients with initial blood glucose values greater than 15 mmol/l. Dots represent mean blood glucose, histogram represents insulin infusion, and bars are 1 SD.

FIG 3—Mean response of 16 patients with initial blood glucose values below 15 mmol/l. Dots represent mean blood glucose, histogram represents insulin infusion, and bars are 1 SD.

to 6 ml in 50 ml of saline mixture reduced the incidence of thrombophlebitis to eight of the remaining 17 patients.

Potassium was measured daily (or more often if indicated). Three plasma potassium determinations after the onset of the insulin infusion were below 3.4 mmol(mEq)/l (the lower limit of normal for our laboratory)—two values of 3.3 mmol/l and one of 3.2 mmol/l—but these were easily corrected.

Mean blood glucose values and rates of infusion of insulin after myocardial infarction

Day	Time	No of patients	Blood glucose (mmol/l $\pm$ 1 SD)	Insulin infusion (U/h $\pm$ 1 SD)
2	0800	24	6.5 $\pm$ 2.5	2.0 $\pm$ 1.2
	1200	24	8.5 $\pm$ 4.3	1.8 $\pm$ 0.9
	1530	23	7.2 $\pm$ 3.7	2.5 $\pm$ 1.2
3	0800	22	6.2 $\pm$ 3.4	1.9 $\pm$ 0.9
	1200	21	8.2 $\pm$ 4.2	2.2 $\pm$ 1.1
	1530	19	9.5 $\pm$ 4.0	2.1 $\pm$ 1.0
4	0800	17	5.8 $\pm$ 2.9	2.2 $\pm$ 1.1
	1200	14	9.2 $\pm$ 3.0	1.8 $\pm$ 1.0

SD = Standard deviation.

Conversion: SI to traditional units—Glucose = 1 mmol/l $\approx$ 18 mg/100 ml.

Discussion

There are two main reasons for using low-dose insulin infusions in diabetics after myocardial infarction. Firstly, it provides a simple way of correcting hyperglycaemia and maintaining normal blood glucose concentrations. Myocardial infarction initiates a series of metabolic changes¹ (secretion of catecholamines,⁵ glucagon,⁶ and corticosteroids⁷ and suppression of insulin secretion⁸) that culminates in an exacerbation of the diabetes which, on occasion, may be difficult to control. Low-dose insulin infusion is an effective and simple way of regulating blood glucose in these patients. Secondly, there are suggestions that raised free fatty acids seen in myocardial infarction may be deleterious: they may cause arrhythmias,⁹ reduce contractility,¹⁰ and increase infarct size by increasing consumption of myocardial oxygen.¹¹ Infusing insulin reduces free fatty acid levels¹² and may prevent any possible damage that they cause.

There were few problems with this regimen. Hypoglycaemia was uncommon, was easily corrected, and did not cause any untoward complications. Hypokalaemia was not a great problem but, as in all patients suffering myocardial infarction, plasma potassium concentration should be frequently monitored. Thrombophlebitis developed at an unacceptably high rate, and this was only partially reduced by using dilute Haemacel and frequently changing infusion sites.

Based on our experience reported here, we have modified our protocol. If the blood glucose exceeds 24 mmol/l we infuse eight units of insulin an hour. To reduce the risk of hypoglycaemia we routinely measure the blood glucose concentration at an additional time (2200), and we monitor it every four hours in all patients receiving more than two units of insulin an hour. We prefer to use a carrier in solution to minimise the problem of adsorption of insulin by the administration set, although we recognise that not all share this view.¹³ More recently we have used albumin as a carrier, and the incidence of thrombophlebitis appears to be less. To improve the control during the transition from intravenous to subcutaneous insulin we continue the intravenous insulin until just before the first subcutaneous dose is given.

Although this protocol results in more work for the nursing staff they strongly favour this regimen because it offers direct, simple, and unambiguous treatment.

We thank the physicians at the General Hospital, Birmingham, for allowing us to study their patients, and gratefully acknowledge the skill, enthusiasm, and hard work of our nursing colleagues without whom this study would not have been possible.

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Letters to a Young Doctor

"Know then thyself"

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If you have explored sufficiently the possible careers in medicine during the two years after graduation you should have in mind an image of the subject that you want to pursue: what it is and what it does and how. You then have to try to match this with the image that you have of yourself. This is the hardest part of all. Getting a balanced view of yourself and your capabilities is never fully possible. You have to make a guesstimate, and there are then three possibilities—that you have it right, that you have overestimated yourself, or that you have underestimated your capabilities. Your academic record will give some idea. It is not very sensible to delude yourself into thinking that you have a high intellectual capacity when your academic grades have been weak, which probably cuts you out of an academic career or a career in research. A steady achievement of high grades and winning many undergraduate prizes may, however, be a positive incentive for an academic career.

What is harder to weigh in the balance has to do with your own personality. The terms that have been used about personality types are introvert, extrovert, convergent and divergent, outgoing, withdrawn, and so on. There is a place for all of these types in medicine, and there is no set pattern for doctors. Nevertheless, very broad patterns may be determined. For instance, some new graduates find that they are uncomfortable in dealing with patients. This can be overcome, yet it would probably be unwise for such people to go into general practice or one of the major clinical disciplines, whereas basic medical sciences might suit such people, or laboratory work in pathology, or radiology, or anaesthesia. All of these specialties have a large clinical component but this is not so obtrusive and all-consuming as in clinical subjects. The emotional component which may be

disturbing to some is usually absent. Again, with experience this can be overcome if the will to do it is there.

Perseverance may be well rewarded in time, but there obviously are fewer barriers to doing well in a career when your internal struggles are at a minimum. This is why it is best to have congruence between the subject and its practice and your personality and academic capability. Progress can then be made with less effort. It is well to make a distinction between work and labour. The first may be hard but enjoyable; the second is toil and lacking in pleasure, even in the final achievement. A career must surely have elements of enjoyment in it. It takes up so much time and lasts for so long.

Some people worry whether they will have the manual aptitudes for surgery. This need not deter anyone. Some may be good at carpentry, but this may be no guide at all for the pursuit of the craft of surgery. The skills needed to be a surgeon are a thing apart from all others, and they may be learnt by experience, by thinking about them, and by application. The bars to a surgical career are more emotional than physical: it appeals or it does not. And there are many branches of surgery that require different kinds of skills, so that those who fancy a career combining mind, eye, and hand should find something to suit them. But it is demanding because it causes high levels of anxiety that are frequently repeated. Robustness in mind and physique is required, and this is not the perquisite of everyone. There is, however, room for all the talents in medicine. None is necessarily more important than the others in contributing to the medical common weal and in benefit to patients.

Strength of purpose

The general intellectual level of doctors is high. As students they are selected essentially for their academic achievements, which at A level are usually higher on average than those of entrants to other university faculties. Medical students go

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