IS WARD BIOCHEMICAL TESTING CHEAP AND EASY?

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Summary

Reagent strip tests ("stick tests") are widely used by nurses and by patients for carrying out biochemical tests in hospitals and in the community and are the simplest form of "bedside biochemistry". A survey at the major hospitals in Reading revealed that more than £48,000 per annum was spent on reagent strip tests for hospital use by the West Berkshire Health Authority, that at least twenty different types of reagent strip and tablet, many duplicating each other, were in use, and that the quality of both urine testing and blood glucose measurement was poor. A major programme of rationalisation, education, and quality control has now been instituted and has involved contributions from and the co-operation of many sections of the hospital service. Both the need for and the attitudes to widespread biochemical testing on the wards have been questioned and an immediate saving in cost and in stockholding has been achieved. However, as yet little improvement in the quality of performance in hospital wards is discernible and the most effective rationalisation of strip test use in outpatient clinics and in the community has yet to be decided.

Keywords: Reagent strip tests; bedside biochemistry; quality control; analytical cost; nursing education.

"The longest journey starts with a single step"
Mao Tse Tung: *The Little Red* Book

In a previous article in this Journal (1), 1 argued that bedside biochemistry, the carrying out of complex analytical procedures by analytically unskilled staff close to the patient; involved both direct costs and hidden costs that were, in part, associated with poor analytical quality. Proponents of bedside biochemistry argue that, with modem instruments, the procedures are within the technical competence of virtually any literate and well motivated person (2). Although doubts have been expressed about this contention (3-6) there have been few published data to support either view.

Reagent strips ("stick tests") are widely used for biochemical tests in hospitals and in the community. Essentially they consist of a plastic strip on which one or more reagent pads are stuck. When the reagent pad is moistened with blood or urine a colour reaction takes place and, after a defined time, the colour of the pad can be compared visually with a colour chart to assess the concentration of an analyte. Alternatively the strip can be placed in a simple reflectance meter which can both assist with timing and produce a numerical display of the concentration of an analyte. Reagent strips are both the simplest and most widespread form of bedside biochemistry. A careful examination of their use therefore gives an insight into the effectiveness of bedside biochemistry and the problems that can be associated with it.

The West Berkshire Health authority serves a population of approximately half a million and has two major and several outlying hospitals. Prior to 1985 there had been little effort to rationalise ward biochemical testing or to assess its quality. Upon moving to the Royal Berkshire Hospital I was asked by the Chief Pharmacists to investigate reagent strip testing as they were concerned about the proliferation of different types of reagent strips and reflectance meters on the wards, about the consequent problems of stock holding, and about the cost.

Proliferation and Cost of Reagent Strips

An initial survey at the major hospitals in Reading (Tables 1 and 2) showed that at least 11 different types of reagent strip were in use on the wards for urine testing and even more were being supplied to outpatient clinics. For blood glucose testing, 5 different types of reagent strip and 4 different types of reflectance meter were in use. There was no rationalisation of reagent strips either within the hospitals or within groups of wards so that a nurse moving from one ward to another could find entirely different systems in use. Even within the same ward different types were in use for the same test. The decisions on which reagent strips should be available on each ward appeared to be made by the nurse in charge, by junior clinical staff, or even possibly by representatives from the manufacturing companies involved in the strips' production. There was little or no involvement of senior clinical or nursing staff. Most of the reflectance meters in use had either been donated by company representatives or bought from ward or trust funds so there had been little control over their acquisition. In 1986 the proliferation increased when several new types of reagent strip and reflectance meter were introduced.

The overall cost of reagent strips to the Health Authority in 1985 was just over £48,000. Although it is difficult to estimate the number of tests that were carried out, it is likely that this was close to 500,000 - an average cost of 10p per test. This figure can be compared with the cost of reagents in this Clinical Biochemistry Department which carried out 1,200,000 tests in 1985 at an average reagent cost of under 7p per test.

Quality of reagent strip tests

To assess the quality of reagent strip testing, two synthetic "urine" samples were distributed to 40 wards at hospitals in Reading. Ward staff were asked to test them by the method that was in routine use on their ward.

The first sample was simply an alkaline salt solution with pH 9.5 and SG 1.037. This was distributed to find out on how many wards the staff were aware that an alkaline urine can produce a false positive protein reaction and an erroneously low SG estimation. From 40 wards there were only two reports that the

Table 1

Some *Urine* Reagent *Strips* in *Use* in *Major Hospitals* in Reading

Multistix SG	Ketodiastix
Ketostix	Diastix
Haemastix	Albustix
Labstix	N-Labstix
Haemocheck	Uristix
Phenistix	BM Test 7

Table 2

Blood Glucose Reagent Strips in *Use* in *Major* Hospitals in *Reading, 1985*

Dextrostix-bottled	Dextrostix-foil wrapped
BM-test 20-800	Reflotest glucose
Reflocheck glucose	Visidex

Reflectance meters for blood glucose reagent strips included the Ames Glucometer and Boehringer's Reflomat, Reflocheck and Reflolux.

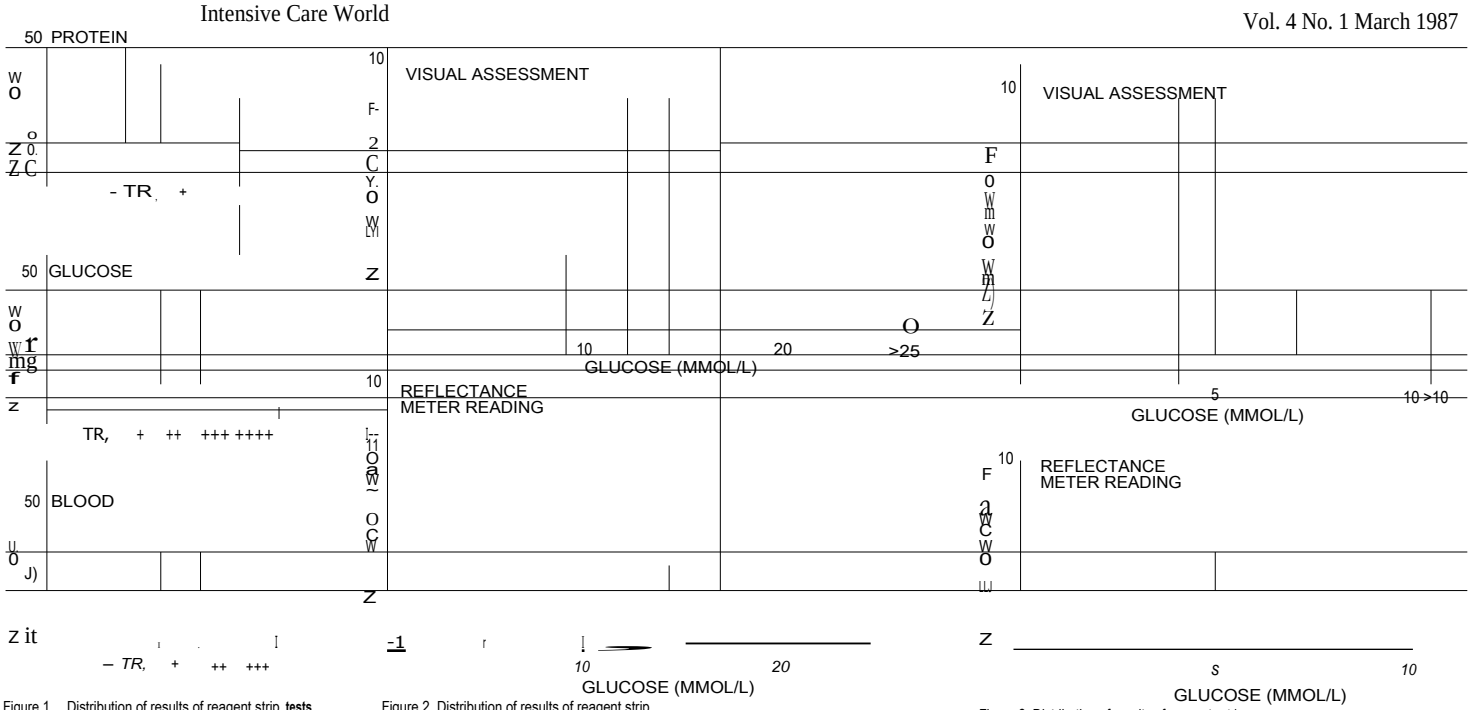

Figure 1. Distribution of results of reagent strip tests for urine constituents

Figure 2. Distribution of results of reagent strip tests for blood glucose. First survey.

Figure 3. Distribution of results of reagent strip tests for blood glucose Second survey.

pH was greater than 8.5 (the maximum point on the pH scale of the reagent strip); one third of the reports recorded a trace of protein to be present and all reports were of an SG of 1.005 or less. There were no comments that these results were false. There was one report of a trace of glucose and one of a trace of bilirubin.

The second sample was more complex; it was an acid salt solution containing traces of protein, glucose, and blood. All the reports provided correct pH values but underestimates of the SG. There was one positive report of bilirubin and one of ketones. The wide scatter of results reported for protein, glucose and blood is shown in Figure 1.

To assess blood glucose measurement, a control serum with a true glucose content of approximately 13 mmol/L was distributed to all wards. The scatter of results obtained is shown in Figure 2. There were two outlying results. One, a result of 0.00, originated from a ward on which the staff failed to recognise an error message (caused by incorrect strip insertion) on their reflectance meter. The other, a result of 180 mmol/L, was probably caused by a confusion of the units, 180 mg/dL being equivalent to 10 mmol/L. The remaining results had a range of 8-18 mmol/L with a between-ward C V of ca 20%. This contrasts with a between-laboratory C V in the UK of less than 10% at this glucose concentration and a between-assay CV within most laboratories of less than 5%.

Subsequent samples were distributed after rationalisation of testing had started but before a major effort had been made on education. On a synthetic urine sample the results for protein, blood, glucose, and pH were very widely scattered. As with the first samples there were some reports of the presence of non-existent constituents. The distribution of results obtained with a serum sample with a glucose concentration ca 4.5 mmol/L is shown in Figure 3. A result of 0.0 originated from one ward and was found to be due to the use of inactive reagent strips although these were within the stated expiry date. Three high results were again found to be caused by a confusion of units. Superficially, the spread of results was smaller than with the first sample but the CV was again close to 20%.

There was no difference of overall performance between the two hospitals taking part in these surveys. Although there was an impression that in intensive care and medical wards the performance was better than in other wards, the difference was not statistically significant. In the testing of urine the performance appeared to be worse in the cases of those analytes which require more accurate timing of the readings. In the case of blood glucose, once outliers had been eliminated, there was better performance in those wards in which reliance was placed on a visual assessment of colour change than in wards in which reflectance meters were in use to obtain, supposedly, more accurate results.

Table 3

Proposals for rationalisation of provision of reagent strips

Reagent strips for urine testing

Ames Labstix for the majority of wards
Ames Multistix SG for paediatric wards
Ames Ketodiastix for diabetic monitoring

Reagent strips for blood glucose measurement

Boehringer BM-test 1-44, read visually for the majority of wards
Boehringer Reflocheck strips and reflectance meter for Intensive Care wards and Diabetic Clinics.

Reasons for Poor Performance

Before the surveys quoted above were carried out there was a widespread feeling in this Health Authority that "reagent strip tests are so simple that nurses require no education in their use". Faced with the evidence of poor performance, surveys were carried out in an attempt to ascertain its causes. The following contributory factors were identified:

1. Outdated stocks

Stocks of reagent strips are kept on all wards. Despite frequent visits by sales representatives to remove outdated stocks, some bottles of reagent strips were apparently in use after their expiry dates. This problem was not unique to wards; several bottles of outdated reagent strips were found in use in the Pathology Laboratory!

2. Incorrect storage

It is not generally recognised that the expiry date printed on reagent strip bottles is for the unopened bottles. Once opened the reagents lose activity, particularly if the bottles are kept in damp or warm conditions. Few wards have appropriate storage areas. On no ward was there a record of the date of the opening of bottles; on all wards there was more than one identical bottle of reagent strips in use simultaneously; on few wards were the bottles capped tightly; and on one ward reagent strips from an uncapped bottle were in use.

3. Incorrect procedures

Different procedures are necessary with different types of reagent strip: some require rinsing, some wiping, and some blotting; and for some the timing of reading is more critical than for others. With a multiplicity of different types of strip in use it

was not surprising that many examples were found of the use of inappropriate procedures.

4. Incorrect use of reflectance meters

Almost all wards had at least one reflectance meter available for the measurement of blood glucose. Few meters were being regularly maintained or calibrated; many were contaminated with dried blood and fewer than half were being used at all, mainly because many nurses felt that they were unreliable. On some wards equipped with reflectance meters the staff were found to be inserting the wrong type of reagent strip for which, of course, the meters were not calibrated.

Recommendations for Improvement

Having identified the problem, the staffs of the Clinical Biochemistry and Pharmacy Departments approached senior clinicians, senior nurses, and nurse tutors, and a series of recommendations was produced. These recommendations have been extensively discussed by the staff of the clinical specialities and the appropriate advisory groups. Most people involved have welcomed the recommendations which are now being put into effect. They cover the need for rationalisation, for education, and for control.

1. Rationalisation

Our proposals for rationalisation are summarised in Table 3. For urine testing on all wards surveyed there was a policy of carrying out a biochemical screen on all new patients using Ames Multistix SG. Neither senior clinical, nursing, pathology, nor pharmaceutical staff had apparently originated this policy and Multistix SG are expensive and difficult to use. The majority of clinicians supported rationalisation towards a cheaper and simpler reagent strip for ward use and Ames Labstix were chosen. However, the paediatricians believed that, for their more specialised needs, Multistix SG were preferable. For the purposes of monitoring diabetics there seemed no reason to retain Ames Ketostix and Diastix as well as Ketodiastix which combine both tests. Although the last is slightly more expensive the extra cost is more than outweighed by the lower costs of stockholding and of discarding unused and outdated strips. Similarly, there seemed no reason to retain on the wards individual test reagent strips since their use was covered by Labstix.

For blood glucose, it was decided that on the majority of wards this should be monitored visually by means of the Boehringer BM test 1-44 (which replaced BM test 20-800 in 1986). For a minority of wards and clinics (such as Intensive Care, Day wards and Diabetic Clinics) it was felt that an automated assessment may be better. The reflectance meter preferred was the Boehringer Reflocheck which appeared to be more reliable and more foolproof (but more expensive) than competing meters.

2. Education

It was clear than an education programme in the use of reagent strips was needed. After extensive discussions it was decided that all new nurses should receive some tuition in their Induction Course. In addition it was agreed that at each hospital there should be a biochemical task force which would have both scientific and nursing representatives. This task force would make regular visits to every ward, would discuss any immediate problems, survey stocks, and ensure that any new staff on duty knew the procedures to be followed. In addition a regular quality assessment programme would be established by the staff of the Clinical Biochemistry Department. This would consist of a monthly distribution of quality control material either for blood glucose estimation or - for urine testing, the collation of the results, and discussion of the results both with senior nurses and with staff on individual wards.

The establishment of biochemical task forces and a quality assessment scheme are not cheap: a considerable expenditure in time is needed and control materials, particularly those suitable for blood glucose measurement, are very expensive. To a certain extent these developments are a matter of faith. Not surprisingly there has been some resistance to the idea of quality assessment and there is as yet little discernible improvement in the results that are being obtained. However, experience of quality control schemes for clinical biochemistry laboratories has suggested that the most important single factor governing the quality of results is the attitude of the staff carrying out the tests and that many months may elapse before an overall improvement in quality is apparent.

3. Control

New reagent strips are frequently introduced by the companies involved in their manufacture. At many hospitals there is no overall responsibility for their use so it is not surprising that some sales representatives deal directly with relatively junior staff on the wards. Without some control this results in an expensive proliferation of strip types and subsequent confusion about which tests should be carried out and which is the `preferred method'. We are trying to control the situation by insisting that the introduction of any new type of reagent strip must be discussed with senior nurses and the strip must be assessed in the Clinical Biochemistry and Pharmacy Departments. If it offers significant improvements over the currently recommended item it must be approved by the Medical Advisory Committee before being made available on the wards. The great majority of clinical and nursing staff have accepted the need for this and accept that any new type of strip should have an assessment of its clinical utility, its quality, and its cost, before it is introduced.

Conclusions

The West Berkshire Health Authority is typical of many in the United Kingdom and its hospitals typical of many in the world. Ward biochemical testing using reagent strips is a useful procedure but, in the absence of rationalisation, of education, and of control, it can result in an expensive proliferation of tests and of strip types and in results which are little better than random numbers. In most hospitals it is not clear who should exercise control of ward reagent strips: clinicians, who may ask for the tests; nurses, who usually carry them out; biochemical staff, who may assess their quality; or pharmacy departments, which may stock them. In this Health Authority we have shown that major problems exist with the use of reagent strips on wards. The solutions are complex and expensive and we feel can only be taken with the involvement of all groups of staff concerned. Although rationalisation by itself has produced a saving of at least 15% of the total reagent strip cost, we have yet to show that the education programme produces an improvement in the quality of the results or that the control measures are effective. In addition, the use of reagent strips in outpatient departments, and in the Community poses a further set of problems and agreement has yet to be reached on rationalisation in these areas.

Ward reagent strip testing is probably the simplest form of bedside biochemistry. If there are so many problems with this, what difficulties are likely to be associated with more complex procedures carried out by analytically unskilled staff at a patient's bedside?

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References

1. *Challand G (1984)* Bedside biochemistry *-the cost of convenience.* **Intensive Care World** 1: *32-34.*
2. *Marks V (1983)* Clinical biochemistry nearer the patient. **Br Med J** *286:1166-116Z*
3. *M=e R S, Shamoon H, Pasmantier R, et al. (1984)* Reliability *of* blood glucose *monitoring* by *patients with* diabetes *mellitus.* **Amer J Med** *77: 211-217.*
4. *Fyffe J (March 1986) Stick testing: a cause for* concern. **Br J Hosp Med** *196.*
5. *Hilton A (April 30 1986)* Monitoring blood glucose levels. **Nursing Times** *55-56.*
6. *Almond J (October 81986)* Measuring blood glucose levels. **Nursing Times** *51-54.*