Chapter 19: Diabetes in Patients with Established Renal Failure: Demographics, Survival and Biochemical parameters

Summary

- The Renal Association has recommended HbA1c levels of <7% in ERF patients. This is only achieved in 47% of HD, 25% of PD and 33% of transplanted patients with diabetes.

- Of prevalent transplant patients, only 7% have diabetes at the start of renal replacement therapy. 28% of diabetic patients on RRT have a functioning graft.

- Diabetic patients have significantly lower survival rates over 6 years compared with non-diabetics irrespective of age. The discrepancy is greatest in younger patients (76% of non-diabetics aged 18–34 alive at 6 years compared with 42% of diabetics).

- Diabetic patients are more likely to have associated co-morbidity at the start of renal replacement therapy than non-diabetics (45% v 36%, $p < 0.001$).

- Cardio-vascular, cerebrovascular and peripheral vascular disease were all more common in diabetics as an associated co-morbidity than in non-diabetics, $p < 0.001$.

- Diabetic patients have significantly lower median serum cholesterol levels compared with non-diabetics (4.4 mmol/L v 4.8mmol/L $p = < 0.0001$). They were also significantly lower within each modality (HD $p = 0.004$, PD $p = 0.003$, transplant $p = <0.0001$). HD patients have lower median levels than PD or transplant patients, irrespective of diabetic status.

- Diabetic patients with ERF are more likely to have higher Townsend scores, suggesting increased social deprivation, when compared with either the general population of England and Wales, or non-diabetic patients on renal replacement therapy ($p < 0.0001$).

- Systolic blood pressure was 10 mmHg higher in diabetic patients on HD and PD than in non-diabetics ($p < 0.0005$). There was no difference in diastolic blood pressure.

- After adjusting patient survival for age, ethnicity, social deprivation and co-morbidity (cardiovascular, peripheral vascular, smoking, malignancy, COPD), diabetes remained a significant factor in the Cox model.

- Many renal units do not provide information relating to HbA1c levels in diabetics to the UK Renal Registry.

- The majority of laboratories linked to renal units align their measurement of HbA1c with the USA assay used in the Diabetes Control and Complications Trial (DCCT study). Practice may change in future years following the introduction of international standardisation.

Introduction

Diabetes is the commonest identifiable cause of established renal failure (ERF) in the UK, accounting for 18% of new patients starting renal replacement therapy (RRT) (see Chapter 4) and 11% of prevalent renal patients: there was considerable variation between units (Table 19.1).

In England & Wales the proportion of patients with diabetes as the primary cause of renal failure is lower than that of many other developed countries (Table 19.2).

Table 19.1. Diabetes at start of RRT by modality in prevalent patients

Renal Unit	% Dialysis pats with DM (no.)	% Transplant pats with DM (no.)	% All RRT with DM (no.)
Kings	29 (97)	17 (41)	24 (138)
Reading	21 (42)	N/A	21 (42)
Wolves	21 (59)	8 (7)	18 (66)
Bradford	27 (37)	6 (6)	18 (43)
H&C	23 (157)	8 (34)	18 (191)
Hull	18 (59)	9 (17)	15 (76)
Clwyd	20 (12)	4 (1)	15 (13)
Sunderland	17 (22)	10 (13)	14 (35)
Nottingham	20 (87)	7 (27)	14 (114)
Coventry	18 (56)	6 (16)	13 (72)
Truro	14 (22)	8 (5)	13 (27)
Guys	20 (99)	8 (60)	13 (159)
Preston	14 (58)	6 (12)	12 (70)
Swansea	16 (46)	3 (3)	12 (49)
Plymouth	15 (27)	9 (20)	12 (47)
Carshalton	14 (63)	7 (24)	11 (87)
Stevenage	12 (46)	7 (10)	11 (56)
Middlesbrough	18 (43)	4 (12)	11 (55)
Ipswich	16 (20)	5 (4)	11 (24)
Southend	12 (18)	7 (2)	11 (20)
Liverpool	15 (80)	8 (48)	11 (128)
Portsmouth	14 (59)	7 (40)	10 (99)
Bristol	13 (57)	7 (40)	10 (97)
Cambridge	13 (42)	8 (31)	10 (73)
Heartlands	13 (39)	5 (9)	10 (48)
LGI	12 (22)	9 (14)	10 (36)
Wrexham	11 (18)	9 (4)	10 (22)
Carlisle	13 (11)	7 (6)	10 (17)
Leicester	14 (83)	5 (24)	10 (107)
Sheffield	13 (78)	7 (28)	10 (106)
St James	13 (58)	5 (26)	9 (84)
Bangor	9 (8)	N/A	9 (8)
Wordsley	14 (20)	1 (1)	9 (21)
Oxford	13 (69)	7 (56)	9 (125)
Cardiff	11 (57)	6 (37)	8 (94)
Gloucester	15 (9)	6 (3)	8 (18)
Newcastle	11 (21)	6 (28)	7 (49)
Exeter	8 (24)	5 (10)	7 (34)
Wirral	6 (8)	N/A	6 (8)
York	6 (7)	3 (1)	5 (8)
England	16 (1705)	7 (675)	12 (2380)
Wales	13 (141)	6 (45)	10 (186)
Eng & Wales	15 (1846)	7 (720)	11 (2566)

Table 19.2. New patients starting RRT by country: total and diabetic

Country	Year	Population (millions)	Acceptance ERF pmp	Accepted ERF with diabetes pmp	% Accepted with diabetes
Australia	2002	19.6	94	25	26
Austria	2001	8.1	137	44	32.1
Canada	2001	31.4	152	51	33.3
Germany	2001	82.5	184	67	36.2
Italy	2001	57.9	136	24	17.4
Japan	2001	127.1	252	96	38.1
New Zealand	2002	3.9	115	52	45
Norway	2001	4.5	95	14	14.5
Sweden	2001	8.9	124	31	25.2
United Kingdom	**2002**	**59.2**	**101**	**18**	**18**
USA	2001	285.3	334	148	44.3

The Renal Association Standards 3rd edition does not specify the frequency of measurements but recommends that:

> ***Diabetic patients on dialysis should aim for HbA1c levels <7%, measured using an assay method that has been harmonised to the DCCT standard.***

Other organisations have also issued recommended standards;

1. The UK National Service Framework (NSF) for diabetes recommends that ‘health professionals should work in partnership with people with diabetes to achieve the best possible level of metabolic control, with HbA1c stabilised in the normal range’. Ideally an HbA1c of less than 7.0% (DCCT-aligned) should be achieved by the end of the first year after diagnosis. The frequency of blood glucose monitoring should be ‘reviewed regularly at intervals negotiated between the person with diabetes and those providing their diabetes care’, but usually at least once every six months and more frequently in young adults and in those whose control is sub-optimal.
2. The US Diabetes Association recommends measurement of HbA1c four times a year.
3. The European Best Practice Guidelines for Transplantation recommend that HbA1c should be measured 3 monthly.

For this report the Registry has analysed HbA1c data from those centres that have provided at least 50% data returns for respective modalities of treatment, and several new validation processes have arisen as a consequence. Survival rates in diabetic incident patients over the last 6 years have been calculated and compared with non-diabetics, together with co-morbidity data, serum cholesterol levels, transplantation rates and social deprivation levels.

Glycated haemoglobin assay

Glycated haemoglobin is measured as HbA1c and is the result of an irreversible non-enzymatic glycation of the beta chain of haemoglobin A. In people who do not have diabetes, 3–6 % of their haemoglobin is in the form of HbA1c. There are more than 20 assays currently in use using a range of techniques, including cation-exchange chromatography, electrophoresis, affinity chromatography and immunoassays. Each of these techniques measures a different fraction of the glycated haemoglobin.

In 2000 a consensus statement paper was published which recommended that HbA1c assays should be adjusted to produce HbA1c results that are aligned to the assay systems (cation-exchange HPLC method) used in the US for the Diabetes Control and Complications Trial (DCCT). Many laboratories in the UK have followed this guidance.[1]

In January 2002 the International Federation of Clinical Chemistry & Laboratory Medicine (IFCC) HbA1c working Group published a full reference measurement system for the measurement of HbA1c in human blood. An international network of reference laboratories comprising laboratories from Europe, Japan and the USA has evaluated the analytical performance of the reference method and possible interferences have been carefully investigated. Due to the higher specificity of the reference method, the results are lower than those generated with most of the currently available commercial methods. The new reference method has been approved by the member societies of the IFCC and will be the basis for standardization of HbA1c assays worldwide in the future.[2]

UK centres use a range of different assays, not all of which are DCCT aligned (Table 19.4 at the end of this chapter). A questionnaire compiled by Elizabeth Burgess (Clinical Biochemist, Gloucestershire Hospitals NHS Trust) was sent out to each of the laboratories based in hospitals with renal units that subscribe to the Renal Registry. Information was obtained about the precise method used for measurement of HbA1c and whether it was DCCT aligned or calibrated by some other method. The reference range and comments that related to it on the printed results were also requested. The responses, outlined in Table 19.5 at the end of this chapter, show that 7 different assay systems (using either ion exchange chromatography or boronate affinity chromatography as assay principle) were in use during 2002. Of 38 replies from the 42 laboratories questioned 34 used an assay that was DCCT aligned whilst the other 4 used an alternative method for calibration. It is not possible to directly compare HbA1c levels between centres that are not DCCT aligned with DCCT aligned assays, but the results from these centres have been included to help inform local service provision. Only one centre (Carshalton) using a non-DCCT aligned assay provided sufficient HbA1c data on their patients with diabetes to be included in the analyses.

Data validation of glycated haemoglobin

Before the data could be analysed, the Registry had to ensure that only measurements of HbA1c from diabetic patients were included. Initially many centres were found to have a median HbA1c that was within the normal range of individuals who are not diabetic. Many of these measurements had been recorded on patients who were not registered as having diabetes (either as a primary renal diagnosis or as a co-morbidity). A list of patients with an HbA1c > 7% on more than one occasion was compiled from the database as well as a list of patients with a recorded HbA1c = 7% who had not been registered as having diabetes. These patients were grouped by centre and each renal unit contacted by letter and a telephone call to answer four questions about them:

1. Does the patient have diabetes?
2. If so, is this the primary renal diagnosis?
3. If the answer to (2) is no, was diabetes present as a co-morbidity at the start of renal replacement therapy (RRT)?
4. If the answer to (2) and (3) is no, did diabetes arise following transplantation?

In total, 107 of those patients with an HbA1c ≥ 7% who had not originally been registered as diabetic were in fact diabetic; 14 had diabetes as a primary diagnosis (13%), 39 (36%) had diabetes as co-morbidity at start of RRT and 30 (28%) had developed diabetes

following transplantation. 187 were either not diabetic or their diabetic status was unknown (some of these patients had died).

Glycated haemoglobin by RRT modality

Many renal units (Birmingham Heartlands, Cardiff, Gloucester, Hull, Newcastle, Oxford, Preston, Plymouth, Reading, Southend, Swansea, Wordsley and Wrexham) have not provided information about HbA1c levels in their diabetic patients (see Table 19.5 at the end of the chapter). Many centres do not have HbA1c in their automated laboratory link to the renal system. Of those that did, there was wide variation between centres in both median HbA1c levels and the proportion of their diabetic patients achieving Renal Association standards. Of those 1058 diabetic patients who had an HbA1c measured in 2002, 21% had it measured once only, 27% twice only, 27% three times only and a further 25% four times.

Some renal units do not look after transplant and/or peritoneal dialysis patients. The Wirral renal unit only has patients on HD with PD and transplant patients being followed up at Liverpool Royal Infirmary. At Clwyd there were no diabetic patients on PD and both these centres were excluded from the analyses.

Several centres had less than ten diabetic patients on PD, and Carlisle, Bangor and Truro were excluded because they had fewer than 3 patients with diabetes on PD. Overall in England and Wales, diabetic patients on PD had a median HbA1c of 8.0% (Figure 19.1), with variation between centres of 6.4 to 9.0%. The percentage of patients achieving Renal Association targets of HbA1c <7 % on PD ranged from 3 to 60%, with only 25% overall in England and Wales (Figure 19.2). This difference between centres did not reach statistical significance.

Those centres that were able to provide HbA1c results for only a small proportion of their diabetic PD patients also tended to do the same with their HD patients. The median HbA1c of diabetic HD patients in England and Wales was 7.1% (Figure 19.3), but only 6 centres achieved a median reading <7%. The proportion of diabetic HD patients achieving RA standards in the different units varied from 75% to 29% (Figure 19.4, $p < 0.001$). Diabetic patients on haemodialysis had a lower median HbA1c (7.1%) than patients treated with PD and transplant (8%), (Figure 19.1, $p = 0.0009$). This is probably related to the high glucose load associated with PD bags and the weight gain consequent on it. As a result of this poor control, only 25% of diabetic PD patients achieve RA standards (Figure 19.2) compared with 47% of HD patients.

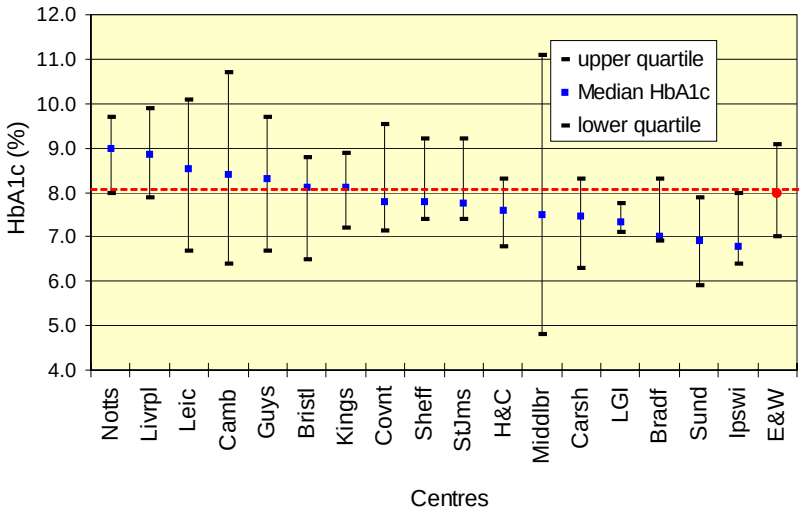

Figure 19.1. Median HbA1c in diabetic patients on PD by centre

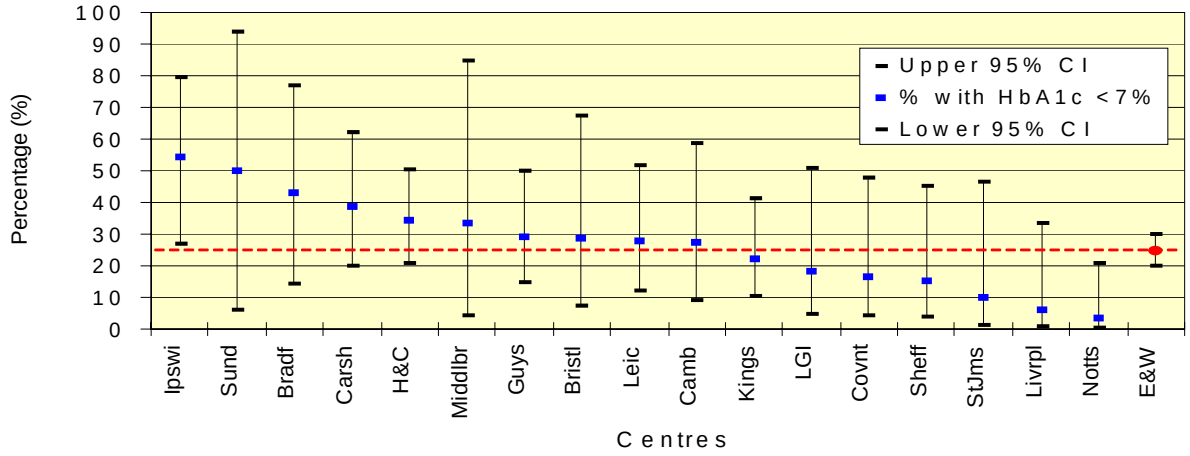

Figure 19.2. Centres achieving RA HbA1c standards in diabetic patients on PD

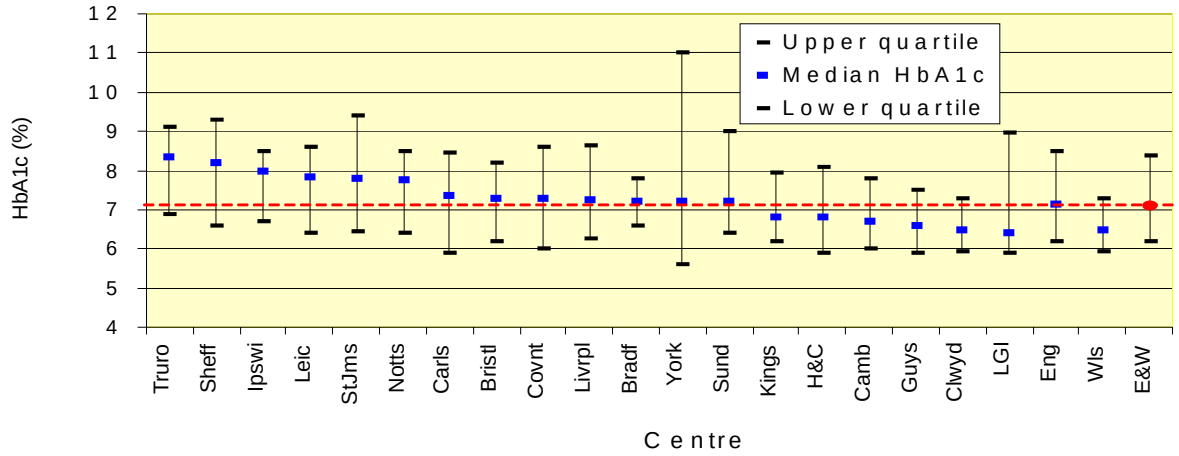

Figure 19.3. Median HbA1c in diabetic patients on HD by centre

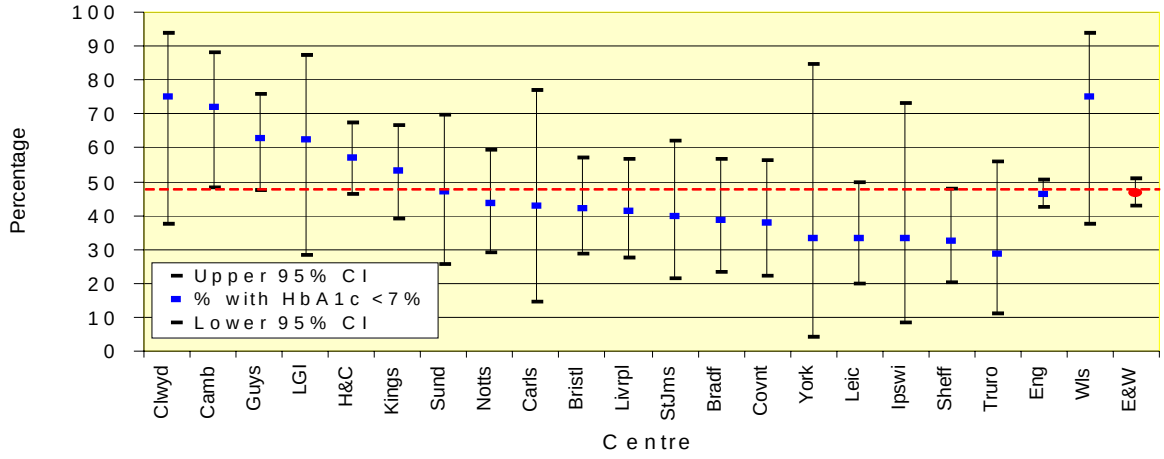

Figure 19.4. Centres achieving RA HbA1c standards in diabetic patients on HD

Only 16 centres sent HbA1c results on ≥50% of their diabetic patients with transplants. This may partly be a result of patients being seen at peripheral transplant clinics whose hospitals do not have automated laboratory links to the main renal unit. This provided a cohort of 382 patients in which the median HbA1c was 7.7% (Figure 19.5). This was not significantly lower than in the PD patients ($p = 0.29$) but significantly higher

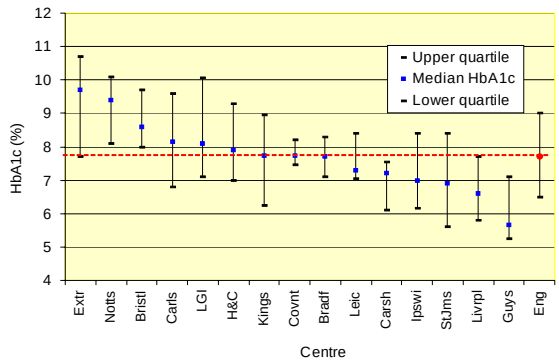

Figure 19.5. Median HbA1c in diabetic patients with a transplant by centre

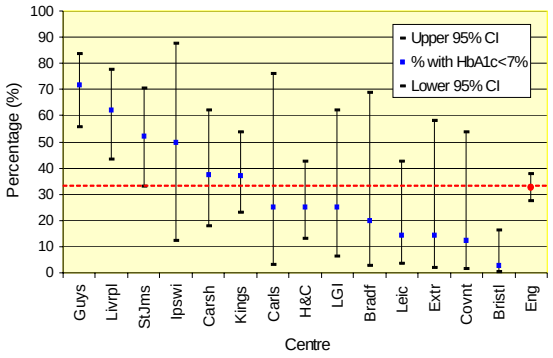

Figure 19.6. Centres achieving RA HbA1c standards in diabetic patients with a transplant

than HD patients ($p < 0.0001$). The median HbA1c between centres (range 9.7–5.7%) varied significantly ($p < 0.001$). Guy's Hospital renal unit with the lowest median HbA1c also had the greatest proportion of diabetic transplant patients meeting Renal Association standards (72%). Overall only 33% of transplant diabetics achieved the target (Figure 19.6).

Survival of diabetic ERF patients

Diabetic patients are known to have an increased risk of death when compared with non-diabetics, although in the study of cause of death in patients with ERF, diabetics had lower death rates in the first 90 days (Chapter 18). Kaplan–Meier graphs were created to show survival rates of diabetic patients on RRT in the first 90 days (Figure 19.7) and over 6 years of RRT (Figure 19.9). By day 90 (Figure 19.7), there were 93% of 18–44 year olds alive compared with 89% of 45–64 year olds and 85% of those aged ≥65.

Figure 19.8 shows the difference in 6 year survival between the diabetics and non diabetics. The diabetics have a younger median age at start of renal replacement therapy (62 years for diabetics and 65 years for non-diabetics) which accounts for the apparent smaller than expected difference in survival between diabetics and non-diabetics. The 6 year survival of diabetics by age band in Figure 19.9 can be compared with the non diabetics by age band in Figure 19.10. In the first 9 months, the youngest diabetic patients had significantly better survival than all other age groups, but by 12 months only 75% of 18–34 year old diabetics were alive on RRT.

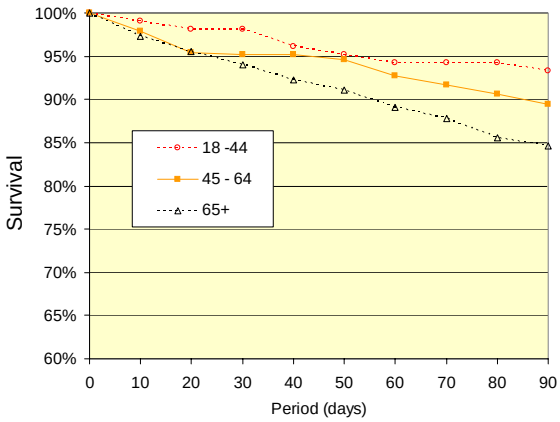

Figure 19.7. Survival of diabetic patients during first 90 days on renal replacement therapy

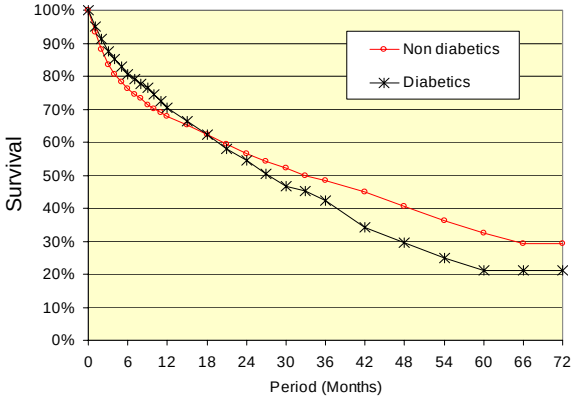

Figure 19.8. 6 year survival of diabetic and non-diabetic patients on RRT

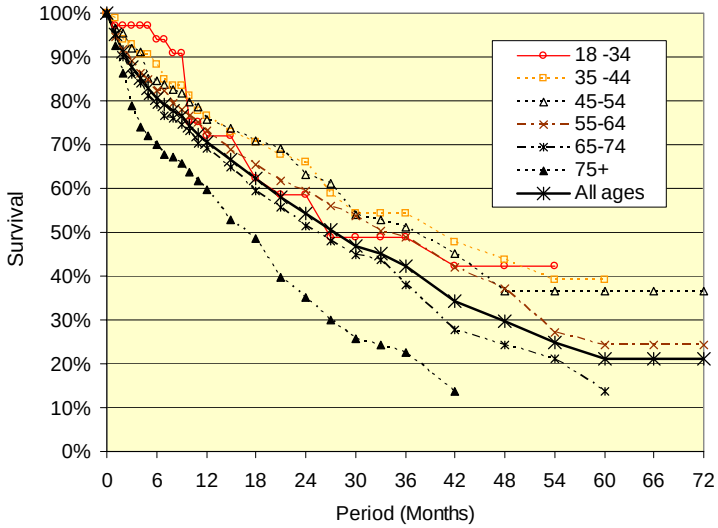

Figure 19.9. 6 year survival of diabetic patients on RRT by age band

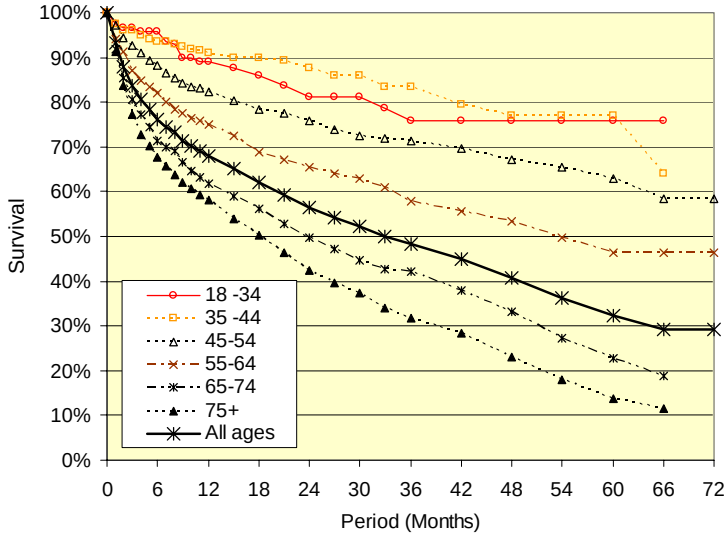

Figure 19.10. 6 year survival of non-diabetic patients on RRT by age band

Compared with non-diabetic patients (Figures 19.9 and 19.10), survival of diabetic ERF patients (Figures 19.7, 19.9) was much lower both overall and by age band. By 6 years, 21% of diabetics on RRT were alive compared with 29% of non-diabetics. The younger the patient, the greater the survival differences (76% of non-diabetics aged 18–34 years alive at 6 years compared with 42% of diabetics), $p < 0.0001$.

Transplantation in diabetic patients

The proportion of patients with diabetes at initiation of RRT with a functioning renal transplant varies considerably across centres (1.1–18.3%, Figure 19.11). Some of this variation is related to the variation between renal units in the incidence of diabetes and diabetic nephropathy in the general popula-

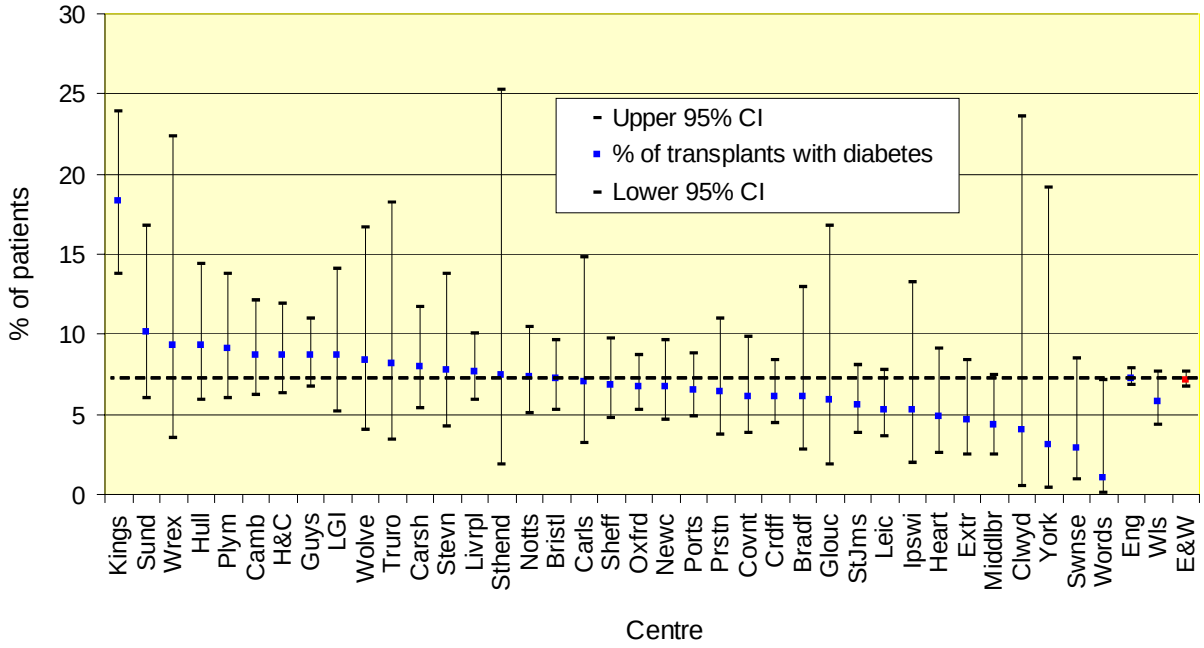

Figure 19.11. Prevalent transplant patients with diabetes as cause of renal failure

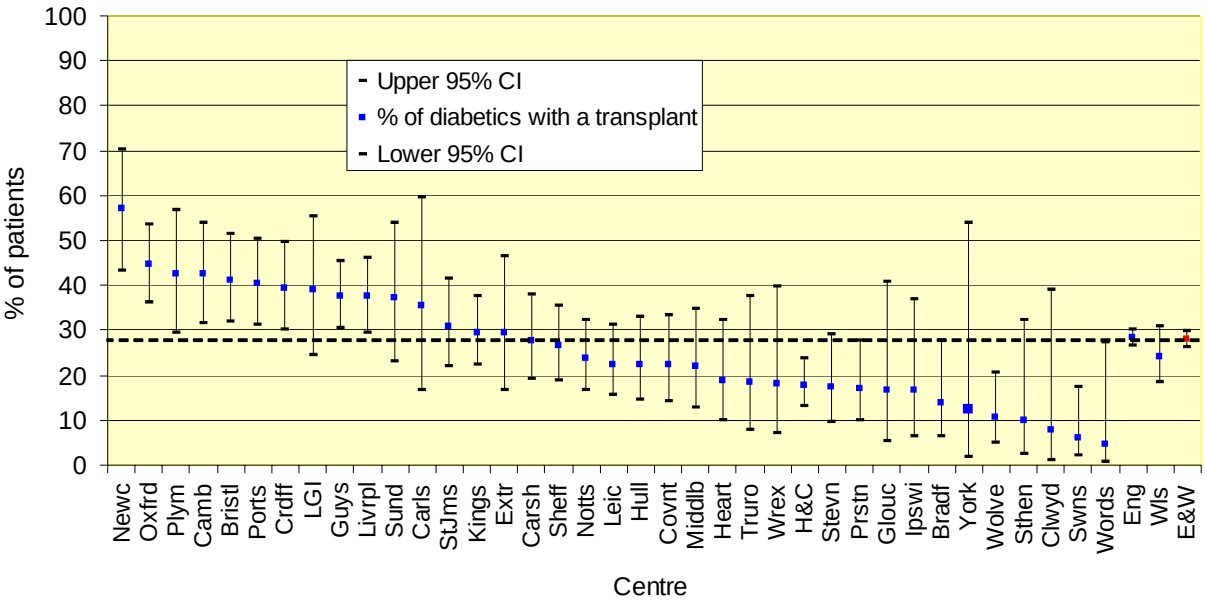

Figure 19.12. Percentage of diabetics on RRT with a functioning transplant

tion. The Kings renal unit had the largest proportion of transplant patients with diabetes (18%) but they also have a large proportion of RRT patients from the ethnic minorities, in whom prevalence of diabetes is high. Guy's unit, with 28% of incident patients from an ethnic minority group however, has only 9% of transplant recipients with diabetes. Overall only 7% of transplant patients have diabetes as the cause of their renal failure.

Figure 19.12 shows the proportion of diabetics with a functioning transplant. In Newcastle, 57% of diabetics have a transplant compared with 28% overall in England and Wales. Further analyses of diabetic transplant patients have been included in Chapter 12.

Co-morbidity in diabetic patients

The data from the 12 centres that had provided co-morbidity information on ≥80% of their incident patients in the years 2001 and 2002 were analysed to assess differences between diabetic and non-diabetic patients. The incident cohort included patients from these centres over the period 1998–2002. The size of the cohort with co-morbidity was 3392. The proportion of diabetic patients at these centres for whom information was available about co-morbidity was similar (63%) to the proportion of non-diabetics (61%).

In the cohort of 3392 patients for whom co-morbidity data was available, the underlying diagnosis appeared to influence the number and type of co-morbidity present on starting renal replacement therapy. As expected, diabetic patients were less likely than others to have no co-morbidity at the start of RRT (45% v 36% respectively, $p < 0.001$) and more likely to have multiple associated co-morbidity (Figure 19.13).

Patients with either polycystic disease or glomerulonephritis were more likely than those with other primary renal diagnoses to have no associated co-morbidity (Table 19.3, $p < 0.001$). By contrast, patients with renovascular disease were more likely to have at least one associated co-morbidity on starting renal replacement therapy ($p < 0.01$).

Figure 19.14 shows the frequency of the different categories of co-morbidity in patients with and without diabetes. Smoking was the most frequent co-morbidity in both diabetic and non-diabetic patients (22% and 20% respectively). Malignancy was more common at the start of renal replacement treatment in non-diabetic (12%) than in dia-

Table 19.3. Range of co-morbidity in ERF patients by primary renal diagnosis

	No. of co-morbidity types present					
	0	**1**	**2**	**3**	**4**	**>4**
Diabetes	36% (213)	23% (134)	19% (114)	10% (59)	7% (42)	5% (33)
GN	55% (243)	30% (133)	9% (38)	4% (20)	2% (7)	0% (4)
PKD	73% (167)	16% (37)	7% (17)	3% (6)	1% (2)	0% (0)
Pyeloneph	51% (151)	32% (93)	12% (34)	4% (12)	1% (3)	0% (2)
Reno-vasc	24% (121)	25% (127)	19% (96)	14% (74)	10% (49)	8% (45)
Other	42% (211)	35% (175)	13% (66)	6% (30)	2% (11)	2% (8)
Uncertain	43% (320)	26% (194)	17% (124)	8% (56)	4% (29)	2% (19)
Missing	45% (33)	22% (16)	18% (13)	11% (8)	4% (3)	0% (0)
Total	43% (1459)	27% (909)	15% (502)	8% (265)	4% (146)	3% (111)

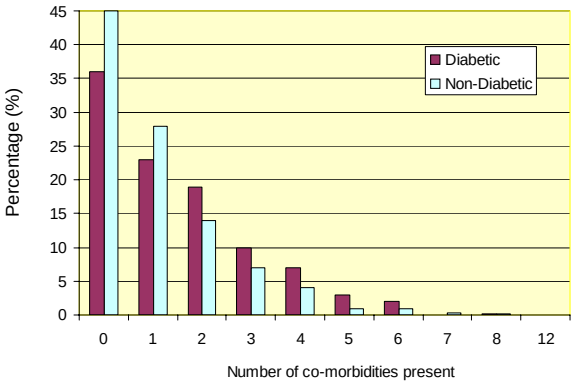

Figure 19.13. Co-morbidity totals for diabetic and non-diabetic RRT patients

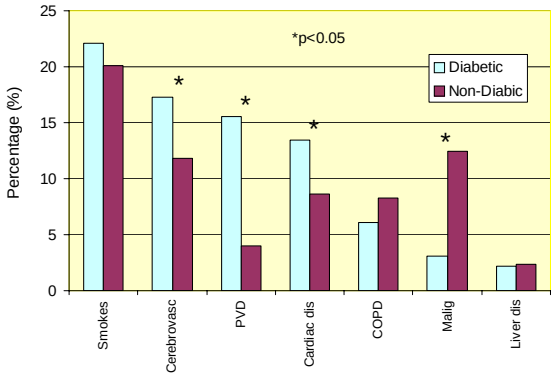

Figure 19.14. Co-morbidity in diabetic and non-diabetic patients starting RRT

betic patients (3%, p < 0.0001). In diabetic ERF patients, cerebrovascular disease, peripheral vascular disease and cardiac disease were all significantly more common at the start of treatment than in non-diabetic patients. For this analysis, cardiac disease included 'angina', 'previous myocardial infarction' (MI) and previous cardiac by-pass grafts. When analysed separately, angina was present in 30% of diabetics at start of RRT compared with 20% of non-diabetics (p < 0.0001) and an MI more than 3 months prior to start of treatment was significantly more common in diabetics (14% v 11%, p = 0.02). There was no difference in the proportion of diabetics and non-diabetics who had suffered an MI less than 3 months before the start of RRT (4% v 3%, p = 0.17); similarly, previous coronary angioplasty was uncommon in both diabetics and non-diabetics (6% v 5% respectively, p = 0.22). Peripheral vascular disease (PVD), which included 'claudication', 'ischaemic and neuropathic ulcers', 'non-cardiac angioplasty' and 'amputations due to ischaemia', was significantly more common in diabetic patients (p < 0.001). The differences in co-morbidity are likely to be one of the explanations for the observed difference in survival between diabetic and non-diabetic patients with ERF.

A Cox proportional hazards model including age (linear variable), ethnicity, primary diagnosis (including diabetes) and co-morbid diagnoses was constructed to analyse incident patient survival, excluding the first 90 day period. In the first model, centres were excluded if they had less than 80% co-morbidity returns (*n* = 1,139). In the second model, all patients from centres returning co-morbidity were included (*n* = 3,206). In both these models, diabetes remained a significant variable in the model after adjusting for co-morbidity (p = 0.02 and p < 0.0001 respectively). Diabetes also remained significant in the second model as a co-morbidity (i.e. not as the primary diagnosis for renal failure), (p = 0.0054).

Serum cholesterol in diabetic patients

The distribution of serum cholesterol between renal replacement modalities has been analysed and discussed in Chapter 11. The analysis below, concentrates on differences between diabetic and non-diabetic ERF patients.

Figure 19.15 shows the distribution of serum cholesterol amongst diabetic and non-diabetic patients on haemodialysis and peritoneal dialysis. There was a significant difference in serum cholesterol between the diabetic and non-diabetic patients across all the modalities (HD p = 0.004, PD p = 0.003, transplant p < 0.0001). Patients on HD, irrespective of their diabetic status have lower serum cholesterol levels than those on PD. Transplant patients have similar serum cholesterol levels to PD patients and significantly lower serum cholesterol than non-diabetics (Figure 19.16).

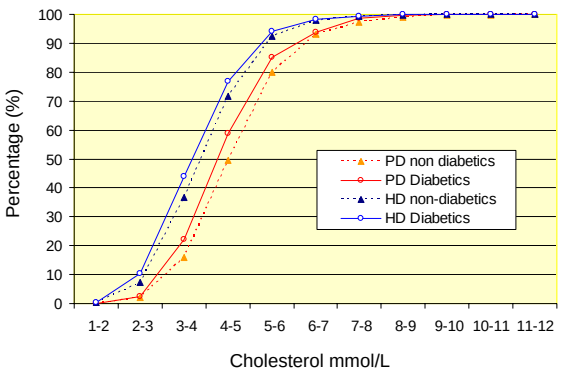

Figure 19.15. Distribution of serum cholesterol by dialysis modality and diabetic status

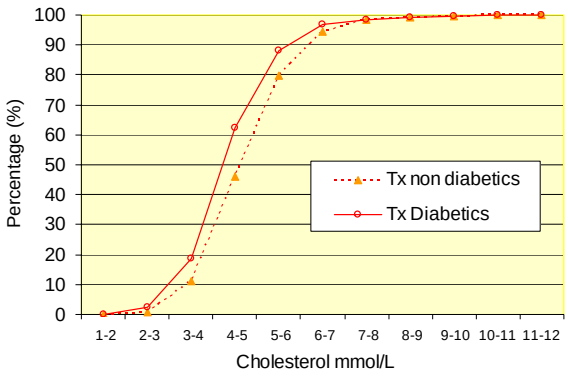

Figure 19.16. Distribution of serum cholesterol in transplant patients by diabetic status

The difference between treatment modalities in diabetics (Figure 19.17) reflects the pattern seen in the non-diabetic population; HD patients tend to have lower serum cholesterol levels than either PD or transplant patients, where levels are similar.

Diabetics on renal replacement therapy had lower median serum cholesterol levels (4.4 mmol/L versus 4.8 mmol/L), compared with non-diabetic patients (Figure 19.18). The pattern followed that of the general distribution with HD patients having the lowest median levels, PD and transplant patients with similar levels (HD 4.2, PD 4.7 and transplant 4.7mmol/L in diabetic patients; HD 4.3, PD 5.0 and transplant 5.0mmol/L in non-diabetic patients) irrespective of diabetic status. The Registry at present does not collect 'statin' usage from affiliated renal units but this may account for the difference in serum cholesterol levels between diabetic and non-diabetic renal patients.

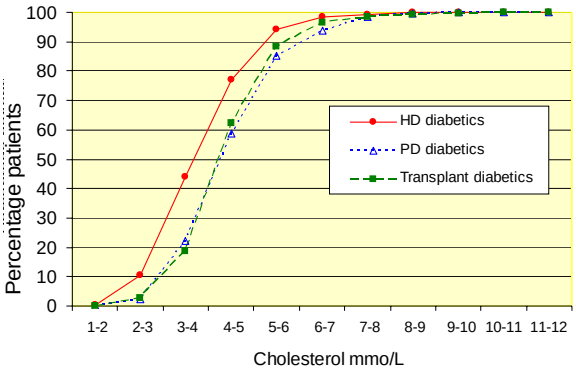

Figure 19.17. Distribution of serum cholesterol in diabetics by treatment modality

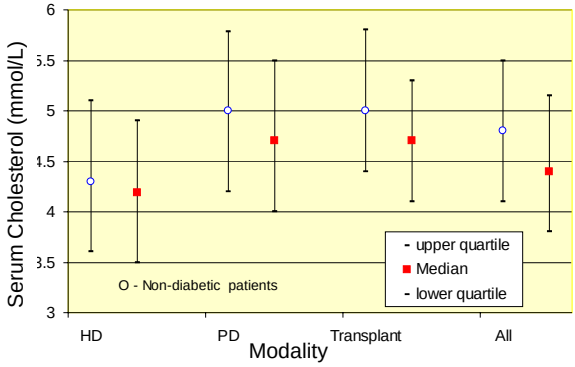

Figure 19.18. Median serum cholesterol by modality in diabetics and non-diabetics

Median blood pressure in diabetic patients

The median systolic blood pressures were 10 mm Hg higher in diabetic patients on HD and PD compared with non diabetics ($p \leq 0.0001$, 0.0003 respectively). Diastolic pressures were not significantly different to non-diabetics. Blood pressure goals in diabetics are lower but this is clearly not being achieved in clinical practice.

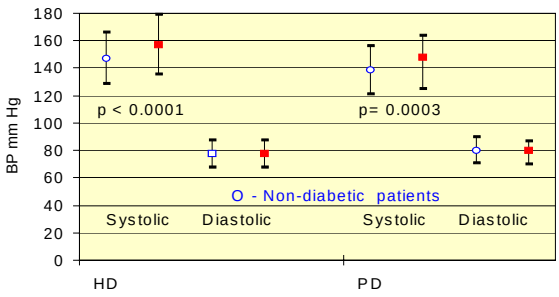

Figure 19.19. Median blood pressure in diabetics and non-diabetics

Social Deprivation in diabetic patients

The Townsend index (calculated for the Registry from the patients' postcode from the 2001 census data, by Hannah Jordan of Southampton University) is a composite measure of social deprivation based on total unemployment rate, no-car households, overcrowded households and not-owner-occupier households based on the electoral ward as at the 2001 Census. The higher the Townsend index, the greater is the social deprivation.

The relationship between social deprivation and diabetic nephropathy was analysed and compared to that of the general population of England and Wales. In this analysis, patients from ethnic minorities on renal replacement therapy were excluded (they have a high incidence of diabetes and are from a more socially deprived group see Chapter 17) so that the cohorts were more comparable.

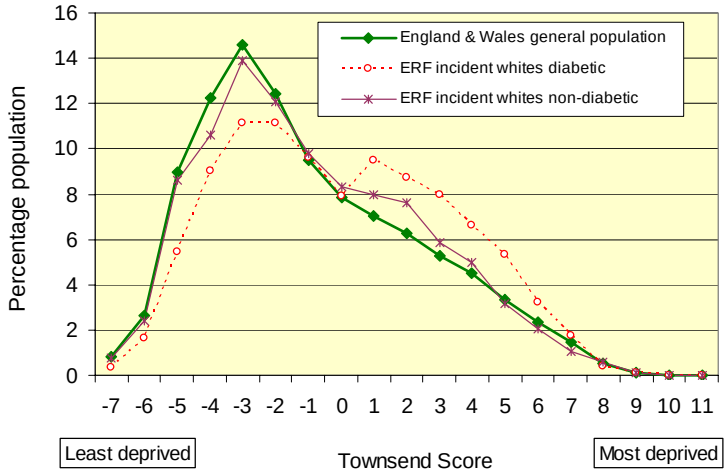

Figure 19.20. Townsend deprivation scores and diabetic status

In the incident cohort, non-diabetic white patients starting RRT closely followed the distribution of the general population (Figure 19.20). This contrasted with the white diabetics, where a significantly higher proportion were from a more socially deprived background ($p \leq 0.0001$). The diabetic cohort were not analysed separately by Type 1 or 2 diabetes. These differences between the diabetics and non-diabetics may be due to the increased incidence of obesity, higher body mass index (BMI) and consequently higher incidence of Type 2 diabetes in more socially deprived groups.

Conclusion

Measurement of HbA1c using DCCT aligned assays remains the mainstay of monitoring and assessing diabetic control. The Renal Association has set target HbA1c levels of <7% in all renal replacement therapy patients in order to minimise further diabetic complications, in particular cardiovascular disease. There have been no recommendations by the Renal Association as to the frequency of this monitoring, although the diabetes NSF recommends at least 6 monthly monitoring. This analysis has highlighted the diversity of glycated haemoglobin assay methodologies used across England and Wales. These differences should resolve once definitive national recommendations for HbA1c assay in the UK have been promulgated.

The percentage of missing HbA1c data was extremely variable between centres and it is hoped that these analyses will help renal units to address this issue. Few diabetic patients are achieving the recommended standard for HbA1c of <7% although this difficulty is not solely confined to patients on renal replacement therapy. The standard was achieved in 47% of HD patients, 25% of PD patients and 33% of transplanted patients. The results in PD patients are possibly due to the high glucose load received in the PD bags, while results in transplant patients may be related to steroids and other immunosuppressant therapies.

Median serum cholesterol levels were significantly lower in diabetic ERF patients irrespective of modality. Diabetic HD patients tend to have lower serum cholesterol levels than those on PD or with a functioning transplant.

The distribution between centres of diabetic ERF patients with a functioning renal transplant varies widely. Some of this variation may relate to the ethnic breakdown of prevalent patients within centres.

The Kaplan–Meier curves confirm published results of lower survival rates in diabetics across all age groups. Although older patients had higher rates of death, the difference between comparable age adjusted diabetic and non-diabetic patients was greatest

in the young. The lower survival rates in diabetics may well be related to the significant difference in both number and type of co-morbidity present on initiation of renal replacement therapy. Diabetics were more likely to have co-morbidity at the start of RRT especially cardio-vascular and peripheral vascular disease. Improved diabetic control prior to and after starting renal replacement therapy may help to improve survival. Further analyses are being undertaken on the importance of diabetic control, blood pressure and cholesterol in diabetic outcomes.

Laboratory glycated haemoglobin reference ranges

Table 19.4. HbA1c assay methodology 2002 by renal unit

Laboratory	DCCT aligned	Range	Reference comment	Assay method
Bangor – Ysbyty Gwynedd	YES	4.6–6.5 %	Reference range applies to non-diabetics only.	Menarini HA – 8160
Birmingham Heartlands Hospital	No	<4.9%		HPLC ion exchange in-house methodology. DCCT aligned values post November 2002
Bradford – St Lukes Hospital	YES	4.4–6.2%		Primus affinity chromatography(hospital) DCA 2000(primary care)
Bristol – Southmead Hospital	YES		Interpretation in adult DM less than 7% is desirable. Greater than 9%, suggest consider review of control.	Menarini HA – 8140 HPLC system
Cambridge – Addenbrookes Hospital	YES	4.9–6.3%	Up to 8.0% acceptable control, 8–10% desirable to improve control, 10–12% poor control >12% very poor control.	Tosoh HPLC analyser
Cardiff – University of Wales Hospital	YES		Non-diabetic age related range determined locally.	Menarini HA – 8140
Carlisle – Cumberland Infirmary	YES	< 6.1% Non-diabetic range	Target for good control 7.0% or less.	HPLC Tosoh G7
Carshalton -St Helier Hospital	No	3.8–6.0%	Indicates satisfactory control.	In house HPLC
Clwyd – Ysbyty Clwyd	YES			Biorad Variant ll
Coventry – Walsgrave Hospital	YES	3.6–6.8%		Biorad Variant II
Derby City Hospital	YES		< 7% is very good control. However the target value should be tailored for each patient to maximize blood glucose control without increasing the risk of hypoglycaemia.	Biorad Variant II
Exeter – Wonford Hospital	YES			Jan–Oct in house HPLC Oct–Dec TOSOH G7
Gloucester Royal Hospital	YES		Adult diabetic control guidelines <7% ideal <8% desirable >9% review.	Primus boronate affinity chromatography

Table 19.4 (continued)

Laboratory	DCCT aligned	Range	Reference comment	Assay method
Hull Royal Infirmary	YES		<7% good glycaemic control, 7–8% borderline glycaemic control, >8% poor glycaemic control.	Menarini HA – 8140
Ipswich Hospital	YES		NICE recommend target HbA1c of 6.5–7.5%. However targets should be individualised, based on risk of micro-vascular complications, risk of hypoglycaemia, personal circumstances..	Biorad Variant II
Leceister General Hospital	YES	4.0–6.1%		Biorad Variant II
Leeds – St James' University Hospital	YES	4.5–6.4%		Primus boronate affinity chromatography
Leeds General Infirmary	YES	4.5–6.4%		Primus boronate affinity chromatography
Liverpool Royal Infirmary	YES	<6.5%	HbA1c <7% target control, >9% poor control, <6.5% good control (non-diabetics).	Menarini HA – 8140 ion exchange
London – Guy's Hospital	YES	4.2–6.2%		Primus boronate affinity chromatography
London – Hammersmith Hospital	YES	4.3–5.5%	Non-diabetic reference range.	Primus boronate affinity chromatography
London – Kings	YES	<6% non-diabetic range		primus boronate affinity chromatography
Middlesborough – James Cook University Hospital	YES	<6.1% for non-diabetic population	Good: 6.5–7.5 Fair 7.5–9 Poor 9–10 Too high >10.	Biorad Variant II
Newcastle – Freeman Hospital				
Nottingham – City Hospital	YES		Very good control: HbA1c less than 7. Good blood sugar control is known to reduce the risk of diabetic complications, but increases the risk of hypoglycamia. Control should be tailored to suit individual patients needs.	Menarini HA – 8140 ion exchange
Oxford – Churchill Hospital	YES	4.3–6.1%		HPLC
Plymouth – Derriford Hospital	YES	.	As a guideline on therapy HbA1c results <7% are considered good, 7–8.5% acceptable, 8.5–9.5% moderate and >9.5% poor	Menarini HA – 8160 ion exchange

Table 19.4 (continued)

Laboratory	DCCT aligned	Range	Reference comment	Assay method
Portsmouth – Queen Alexandra Hospital	YES		The DRIVE guidelines target level for HbA1c is <7.5%,	Menarini HA 8410
Preston – Royal Preston Hospital	YES		well controlled <7%	Tosoh G7 automated HPLC
Reading – Royal Berkshire Hospital	YES		Good control up to 7% and interpretative comment	Biorad Variant II
Sheffield – Northern General Hospital				
Southend – Southend Hospital	YES	<5.5%	>9% poor control 8–9% sub optimal control 7–8% satisfactory control 5.5–7% excellent control	Biorad Variant ll
St Georges Hospital	YES	4.6–6.2%		Biorad Variant II
Stevenage- Lister Hospital				
Stourbridge- Wordsley Hospital	YES	4.6-5.6%		Tosoh G7 automated HPLC
Sunderland Royal Infirmary	YES		Guidance for standards of control: good <6.2% acceptable 6.2–7.5% poor 7.6–9.0% very poor >9.1%.	Menarini HA – 8160 (up to 18/11/02) Arkray 8160 after
Swansea – Morriston Hospital	No	3.5–5.4% for non-diabetic subjects	Use of this test to diagnose diabetes is not advised.	Menarini HA – 8140
Truro – Royal Cornwall Hospital	YES		Good control <7.0% acceptable control 7.0–8.5% moderate control 8.5–9.5% poor >9.5%.	Menarini HA – 8140 ion exchange chromatography
Wirral – Arrowe Park Hospital				
Wolverhampton - Newcross Hospital	No		<6 excellent control 6–<7 good control 7–<8 poor control 8–<10 bad control >10 very bad.	Menarini HA – 8140
Wrexham – Maelor General Hospital	YES	3.2–6.5%		Biorad Variant II
York District Hospital	YES	4.4–6.1%		HPLC tosoh G7

Table 19.5. Percentage completeness of HbA1c data over 9 months by modality

Centre	% HD complete	No of diabetics on HD	% PD complete	No of diabetics on PD	% Transplant complete	No of diabetics transplant
Bangr	0	5	50	2	N/A	N/A
Bradf	100	31	82	11	83	6
Bristl	98	46	100	7	95	40
Camb	60	30	92	12	23	31
Carls	100	8	100	2	67	6
Carsh	35	31	78	23	67	24
Clwyd	89	9	0	1	0	1
Covnt	94	32	60	20	50	16
Crdff	0	42	0	11	0	38
Extr	11	19	100	5	70	10
Glouc	0	8	0	5	0	3
Guys	74	58	74	34	67	60
H&C	88	99	86	44	97	34
Heart	0	31	0	7	0	9
Hull	0	41	0	16	0	17
Ipswi	67	9	100	11	100	4
Kings	84	57	84	32	88	41
Leic	78	46	64	28	67	24
LGI	89	9	100	12	57	14
Livrpl	79	56	80	20	62	47
Middlbr	45	33	50	6	15	13
Newc	0	17	0	6	0	32
Notts	79	53	88	33	58	26
Oxfrd	0	37	0	27	0	56
Plym	0	14	0	11	0	20
Ports	35	43	20	15	33	40
Prstn	0	36	0	15	0	12
Redng	0	15	0	23	N/A	N/A
Sheff	86	51	62	21	46	28
Stevn	0	36	0	6	0	10
Sthend	0	14	0	4	0	2
StJms	61	33	83	12	100	25
Sund	94	18	100	2	23	13
Swnse	0	22	0	22	0	3
Truro	82	17	100	3	60	5
Wirrl	38	8	N/A	N/A	N/A	N/A
Wolve	0	32	5	20	0	7
Words	0	11	0	9	0	1
Wrex	0	12	0	4	0	4
York	60	5	0	1	0	1
All	51	1174	51	543	45	723

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2. Jeppsson J-O, Kobold U, Barr J, Finke A, Hoelzel W, Hoshino T, Miedama K, Mosca A, Mauri P, Paroni R, Thienpont L, Umemoto M, Weykamp C. Approved IFCC reference method for the measurement of HbA1c in human blood. *Clin Chem Lab Med* 2002; 40:78–89

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