Chapter 6: Adequacy of Haemodialysis and Serum Bicarbonate

Summary

- Dialysis adequacy as measured by the urea reduction ratio (URR) continues to rise year on year.
- The URR rises further the longer an individual has been on dialysis.
- Concentrating on adequacy in the first few months after starting dialysis is likely to improve the median URR for a renal unit.
- Achievement of serum bicarbonate Standard is very variable between centres.
- A Registry survey of 8 renal units was unable to account for this variability in pre-haemodialysis serum bicarbonate.

Completeness of data

The Wirral renal unit does not have an automated biochemistry link into the IT renal system (at Liverpool) which accounts for their data being unavailable. The Registry extraction software at Proton sites either extracts the URR if found in the system or it attempts to calculate a URR from two blood samples taken on the same day within the quarter. The inability to identify two blood samples taken on the same day may account for the low levels of URR completeness at some of the sites.

At Cambridge, Coventry, Nottingham and Swansea there are significant differences in the frequency of bicarbonate measurement between HD and PD.

Table 6.1: Data completeness

Centre	URR HD	Bicarbonate HD	Bicarbonate PD	Centre	URR HD	Bicarbonate HD	Bicarbonate PD
Bangr	100	100	92	Middlbr	94	97	100
Bradf	99	100	98	Newc	N/A	97	95
Bristl	97	99	100	Nottm	95	75	47
Camb	37	68	100	Oxfrd	72	82	94
Carls	91	93	94	Plym	77	86	98
Carsh	68	83	95	Ports	83	92	80
Clwyd	75	94	100	Prstn	46	81	81
Covnt	98	17	56	Redng	98	98	100
Crdff	78	75	95	Sheff	98	100	100
Derby	85	89	93	Stevng	77	90	98
Extr	96	97	100	Sthend	90	95	100
Glouc	95	98	100	Sund	96	97	100
Guys	89	97	100	Swnse	36	72	99
H&CX	N/A	98	93	Truro	96	98	91
Heart	86	92	96	Wirrl	N/A	N/A	N/A
Hull	90	91	98	Wolve	93	99	98
Ipswi	100	100	98	Words	96	99	96
Kings	86	93	94	Wrexm	73	83	94
Leeds	96	99	98	York	90	92	100
Leic	97	98	99	Eng	77	87	87
Livrpl	79	84	96	Wls	68	79	96
ManWst	52	0	0	E&W	76	86	88

Dialysis adequacy

Introduction

Although the Renal Association guidelines offer both Kt/V and the URR as markers for the adequacy of dialysis, the Registry has chosen the URR for comparative audit. The Renal Association has endorsed more than one method of sampling for adequacy measurements. The last two Registry reports have confirmed and discussed variability in methodology between units and this is therefore not taken further in this report.

The Renal Association 3rd Standards Document page 17 states that:

HD should take place at least three times per week in nearly all patients. Reduction of dialysis frequency to twice per week because of insufficient dialysis facilities is unacceptable. (Good practice)
Every patient receiving thrice weekly HD should show:

- ***either urea reduction ratio (URR) consistently >65%***
- ***or equilibrated Kt/V of >1.2 (calculated from pre and post-dialysis urea values, duration of dialysis and weight loss during dialysis). (B)***

Recommendations

Patients receiving twice weekly dialysis for reasons of geography should receive a higher sessional dose of dialysis, with a total Kt/V urea (combined residual renal and HD) of >1.8. If this cannot be achieved, then it should be recognised that there is a compromise between the practicalities of dialysis and the patient's long-term health. (Good practice)
Measurement of the 'dose' or 'adequacy' of HD should be performed monthly in all patients. All dialysis units should collect, and report to the Registry, data on pre- and post-dialysis, urea values, duration of dialysis, and weight loss during dialysis. (Good practice)

As in previous years the number preceding the centre name in all the figures indicates the percentage of missing data for that centre.

Achieved URR

The median URR achieved by each unit is shown in figure 6.1. The variability is wide, ranging from over 75% to 62% with a median URR of 71%. This variability is reflected in the proportion of patients in each unit achieving the 65% URR target (figure 6.2) which ranged from 35% to 95% with a median of 77%. This appears not to be due to sampling methodology (early and late sampling methods are indicated on the graphs).

Figure 6.3 shows that the higher the median URR, the higher the percentage of patients whose URR is >65%, although this relationship plateaus once the median URR reaches 73%. To achieve 90% compliance with the RA Standard a median of over 73% is required.

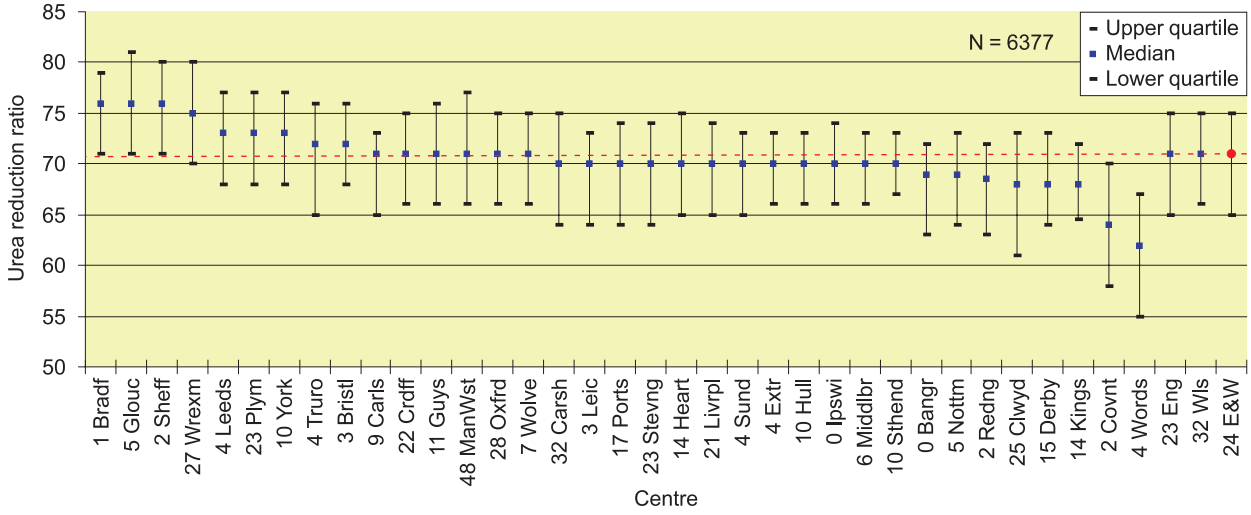

Figure 6.1: Median URR achieved in each renal unit

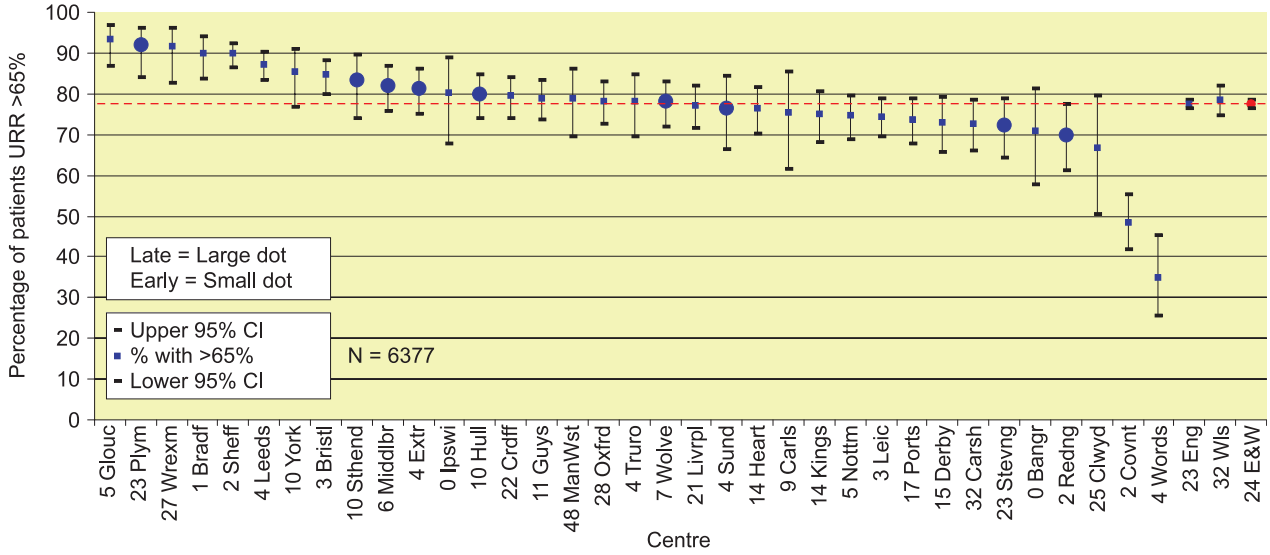

Figure 6.2: Percentage patients, by centre, with a URR of ⩾65% in the last quarter of 2003

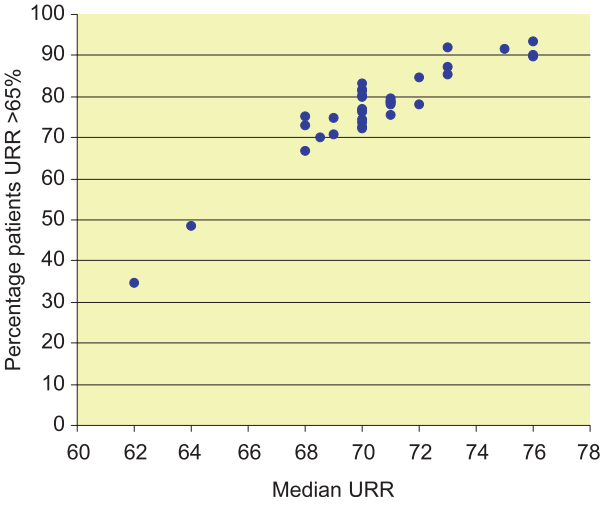

Figure 6.3: URR achievement and median URR at each renal unit

Changes in URR over time

The Registry has data on URR for up to six years (1998–2003), depending on when units joined the Registry. Almost all units have demonstrated an improvement in median URR and percentage compliance with the 65% standard over this time (figures 6.4 and 6.5).

The summary data for England and Wales are shown in figure 6.6 and demonstrate a clear improvement.

Even units starting with a high median URR of 70% such as Plymouth can demonstrate improvement year on year. It is unclear how much the best units are going to be able to improve on current adequacy since the biggest constraint for the thrice weekly dialysed patient is likely to be the dialysis time deliverable or acceptable to patients. The Wordsley renal unit showed a decrease in the percentage of patients achieving RA standards from 52% in 2002 down to 29% in 2003. Informal enquiry has indicated that the unit was already aware of this problem. There had been a reduction in the percentage of patients dialysing through an AV fistula down to only 25% of all HD patients. Similar problems with commissioning vascular access services also affects many other renal units in the UK. At Wordsley, this has now been resolved through commissioning additional on site vascular access sessions.

Nevertheless it is apparent from figure 6.7 that patients in the earlier stages of their dialysis career are less well dialysed. There is wide variation in the URR of patients starting dialysis in different units (figure 6.8). This may be due to more than one factor, unsatisfactory access and possibly a belief in some units that it is necessary to build up to a big clearance working a patient up to the biggest dialyser. Concentrating on patients in the earlier months of dialysis could produce significant changes in median URR and percent compliance with the standard.

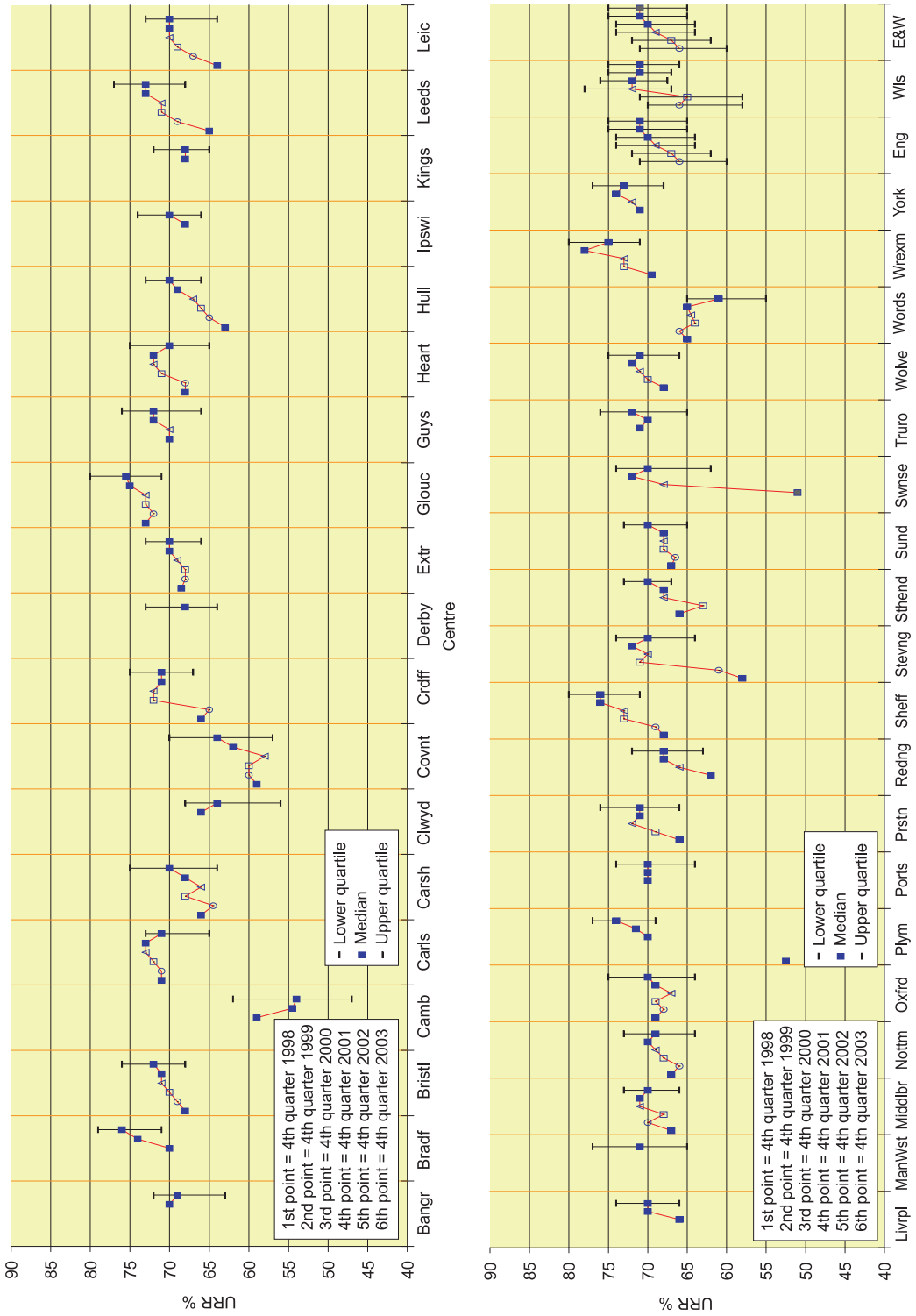

Figure 6.4: Change in meeting the median URR in 1998–2003

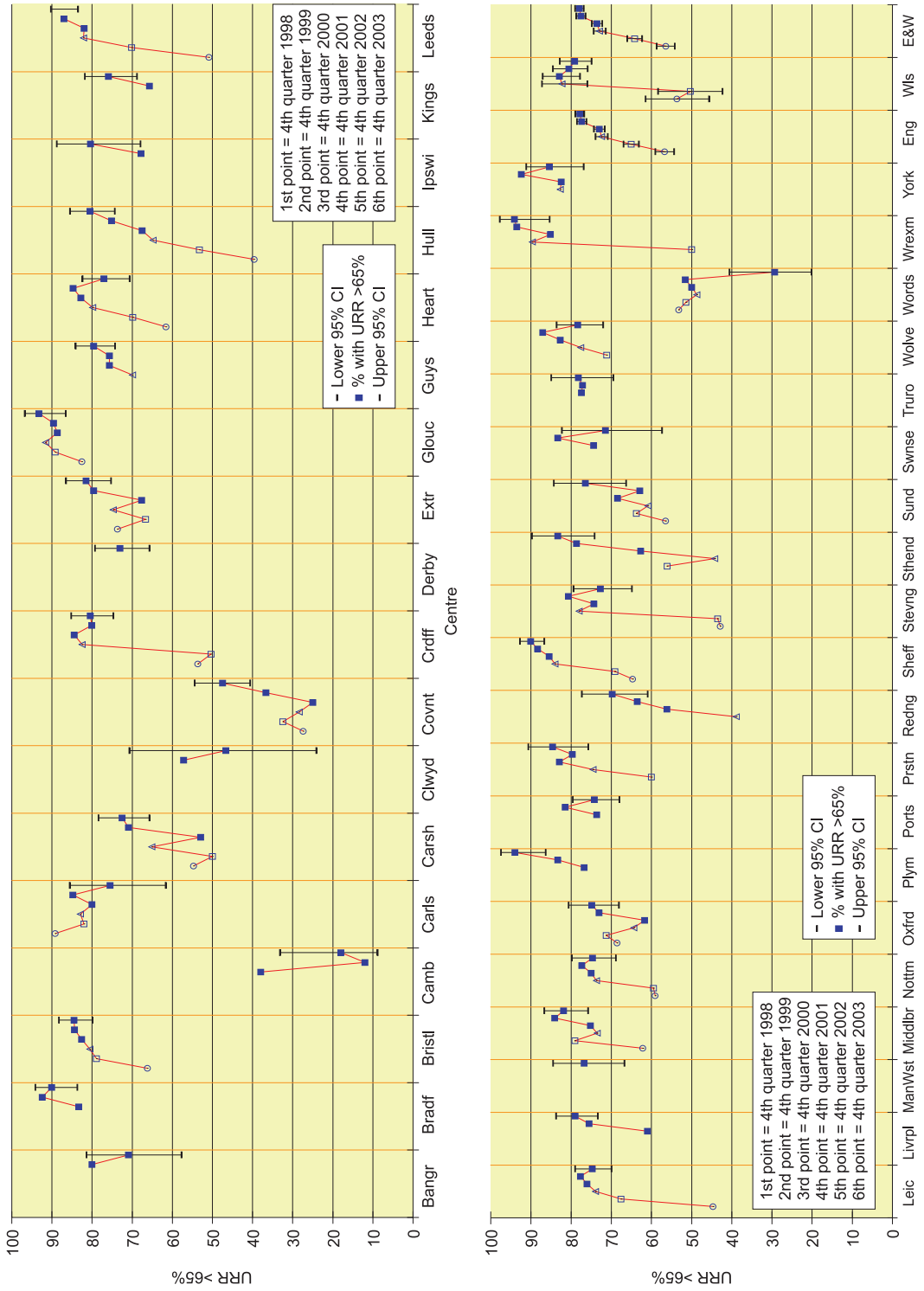

Figure 6.5: Change in meeting the URR Standard in 1998–2003

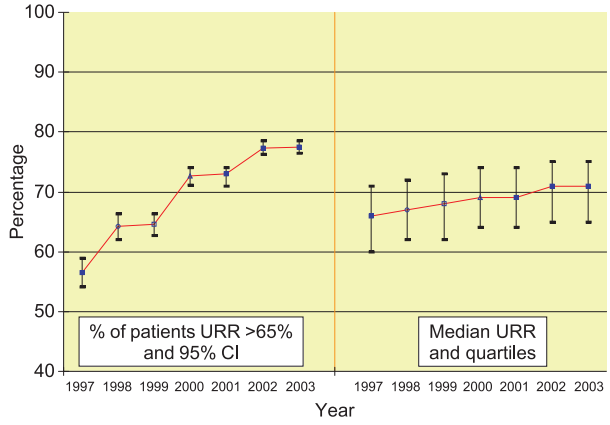

Figure 6.6: Percentage URR over 65% and change in median URR 1997–2003, England & Wales

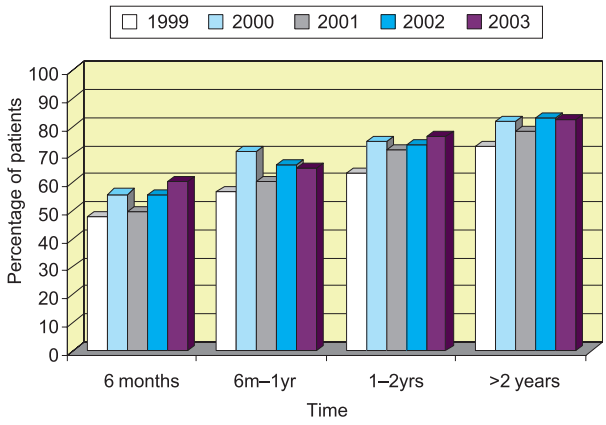

Figure 6.7: Percentage of patients with URR >65% by time on RRT

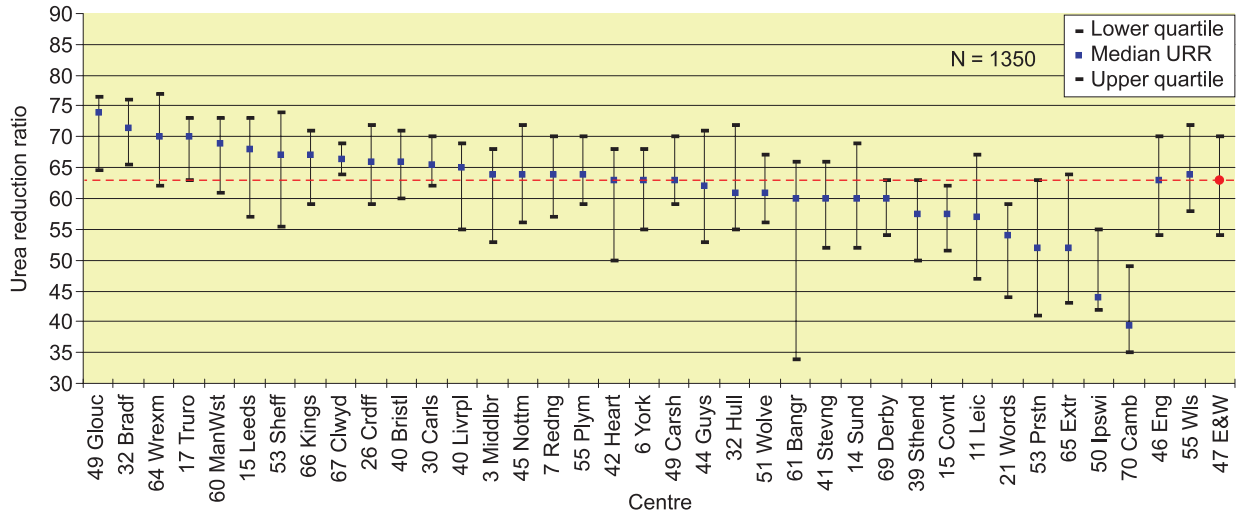

Figure 6.8: URR in patients starting dialysis, by centre

Serum bicarbonate

The current Renal Association guidelines recommend different standards for HD and for PD, based on level C and B evidence:

> ***For HD patients serum bicarbonate, before a haemodialysis session, measured with minimal delay after venepuncture should be between 20 and 26 mmol/L. (C)***
> ***For CAPD patients serum bicarbonate, measured with minimal delay after venepuncture, should be between 25 and 29 mmol/L. (B)***

Haemodialysis

Judged by the median bicarbonate results in figure 6.9, units would appear to be largely compliant with the bicarbonate standard. However the percentage compliance with the standard shows very wide variability (figure 6.10) and this has been investigated further with a specific Registry study reported below.

Peritoneal Dialysis

In peritoneal dialysis patients, the median bicarbonate tends to be higher, 26 mmol/L compared with 23 mmol/L on HD, but there is still wide variability in this and the percentage compliance is shown in figures 6.11 and 6.12.

Change in modality of treatment and serum bicarbonate

The Registry is able to link biochemical data at patient level to details on changes of modality. Patients on PD develop progressively lower serum bicarbonate in the first six months following a switch to haemodialysis (figure 6.13).

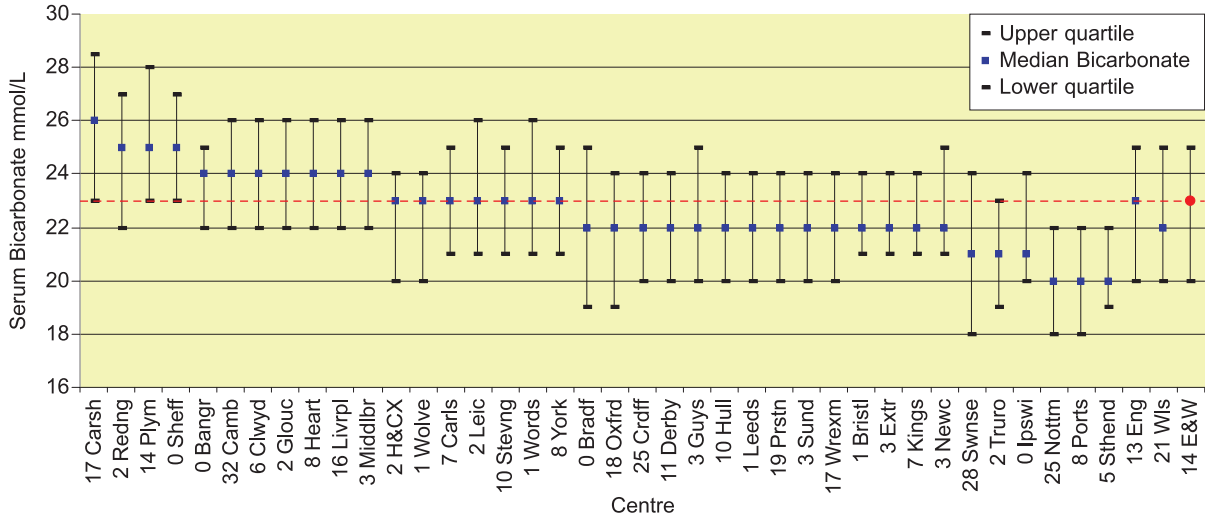

Figure 6.9: Median serum bicarbonate, haemodialysis

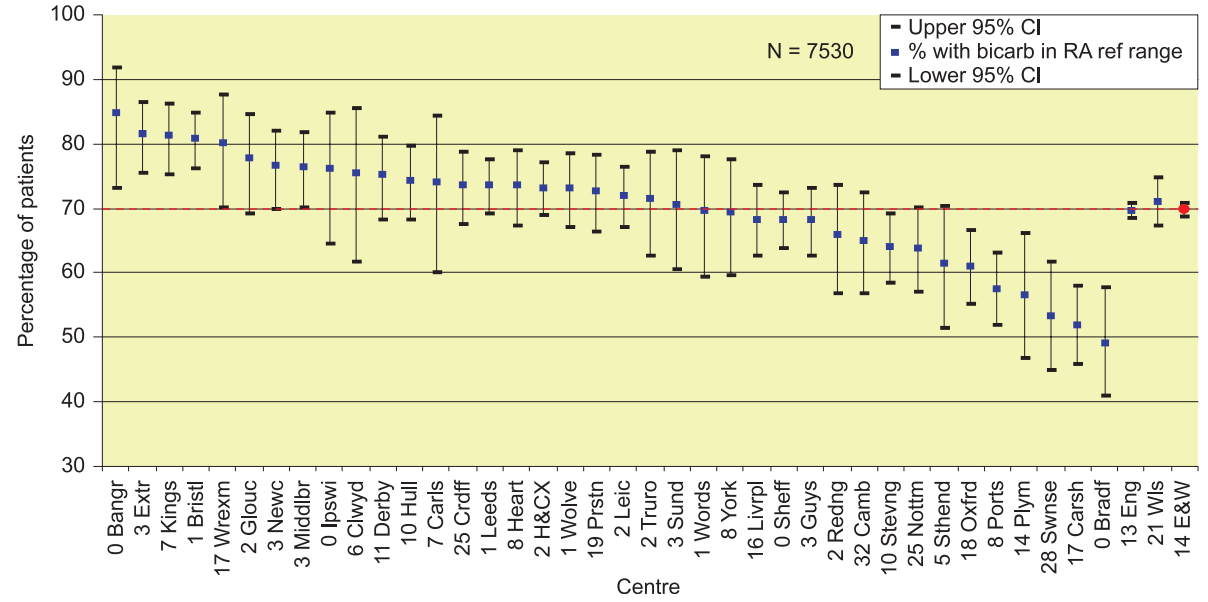

Figure 6.10: Percentage of patients with bicarbonate 20–26 mmol/L, HD

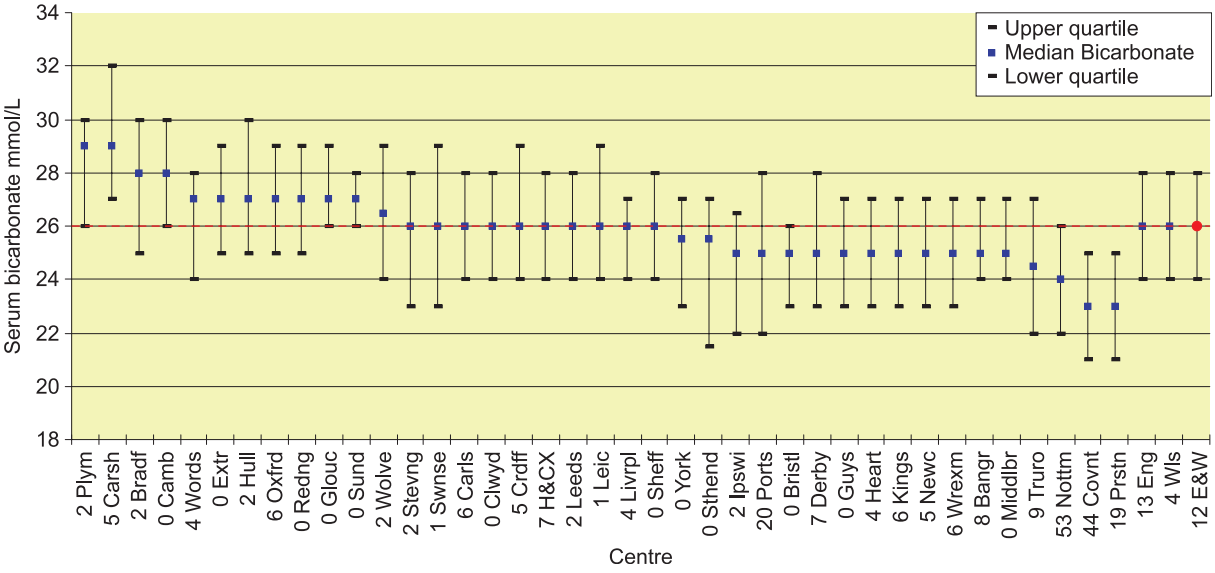

Figure 6.11: Median serum bicarbonate, PD

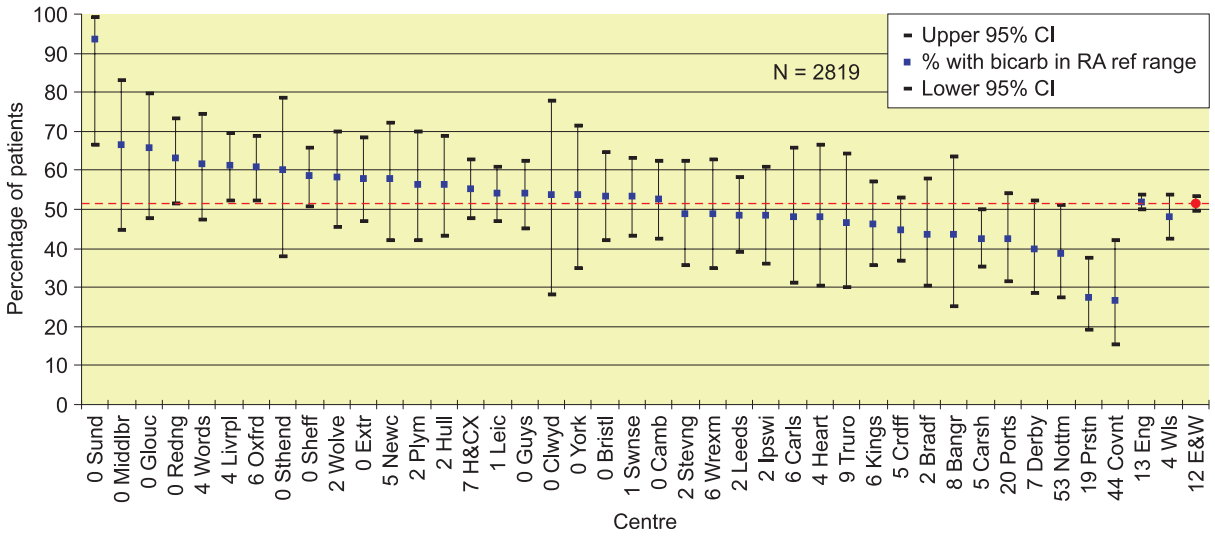

Figure 6.12: Percentage of patients with bicarbonate 25–29 mmol/L, PD

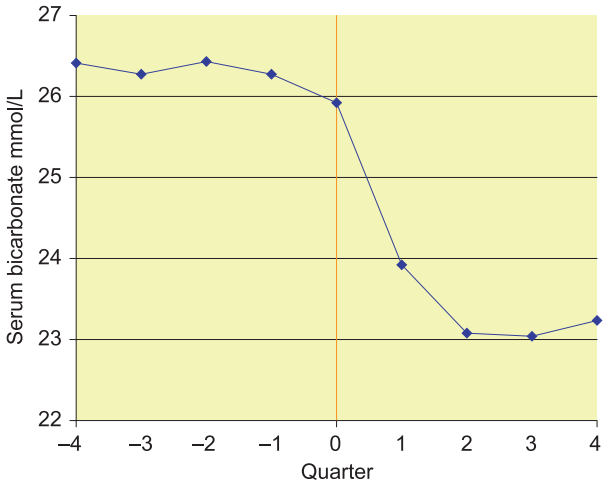

Figure 6.13: Serum bicarbonate after modality change, PD–HD

Inter-unit variability in serum bicarbonate – a Registry survey

Serum bicarbonate values are affected by various patient related and methodological factors. Some of the practical factors affecting bicarbonate measurement are the level of filling of the sample tube, storage of the sample after collection and transportation time to the laboratory. Delays in transport to the laboratories can lead to significant reductions in serum bicarbonate[1].

The Renal Registry has undertaken a survey to investigate the reasons for wide variation in median bicarbonate values among the renal units.

Methods

A structured telephone survey was conducted of eight haemodialysis units, by selection of four centres at each end of the bicarbonate spectrum. The following data were collected

1. Time of sample collection (pre-haemodialysis or post-haemodialysis).
2. Method of filling the tubes (vacuum based tubes or manual syringe).
3. Approximate time delay after collection of sample to reaching the laboratory for analysis (time the blood samples remain in dialysis unit after collection from the patients, mode of transport to laboratory, time to reach laboratory).
4. Average dialysate bicarbonate concentration used.
5. Percentage of patients on thrice weekly HD.
6. Approximate percentage of patients with a neck line.
7. Day of collection of blood sample (long inter-dialytic intervals – Monday and Tuesday vs short inter-dialytic interval – Wednesday and Thursday or Friday and Saturday).

The Kruskal–Wallis non-parametric test was used to test for differences between the two groups (high bicarbonate and low bicarbonate).

Results

In the low bicarbonate group the median pre-HD bicarbonate was 19, 20, 21 and 21 mmol/L respectively compared with 25, 25, 26 and 27 mmol/L in the high bicarbonate group. The median bicarbonate values in the low group were below the normal range for their respective laboratories. Median bicarbonate values were within the laboratory reference range for centres in the high bicarbonate group.

All the samples were collected pre-haemodialysis and were handled by on-site hospital laboratories. Generally vacuum based systems were used for blood sampling, although in some centres manual syringes were used for patients dialysing through a temporary line. One centre in the low bicarbonate group collected the blood samples by syringe only.

The median time delay between collecting blood samples and the samples reaching the laboratory for analysis was 56 min for the low bicarbonate group and 72 min for the high bicarbonate group. This delay includes both the time during which blood samples remained in the dialysis unit after sampling and the time taken to reach the laboratory from the unit. This time difference was not statistically different ($p = 0.38$).

Only one unit used 40 mmol/L bicarbonate dialysate, all the other units used 35 mmol/L bicarbonate as their principal dialysate.

The number of patients on twice a week dialysis differed significantly between the two groups (high group 2.7%, low group 10.2%; $p < 0.00001$).

The low bicarbonate group had 27.5% using neck lines whilst the high bicarbonate group had 12.5% on neck lines. This difference was not however statistically significant. ($p = 0.18$).

In a separate study using data from the Bristol renal unit, the effect of the length of time between dialysis (inter-dialytic interval) on serum bicarbonate was measured. Data were analysed from 559 samples taken after a long inter-dialytic interval (Mon/Tue samples) and 2,239 samples taken after a short interval (Wed/Thu samples). There was no significant difference in the median serum bicarbonate values between these two groups ($p = 0.09$).

Table 6.2: Results of bicarbonate survey

Groups	Low bicarbonate group				High bicarbonate group			
Centre	Nottm	Covnt	Truro	Sthend	Sheff	Glouc	Bangor	Carsh
Lab ref	20–28	24–30	23–29	22–27	22–32	18–26	22–30	24–30
Median bicarb	19	20	21	21	25	25	26	27
Number	181	180	115	104	390	113	59	220
Sample method	Both	Syringe	Vac	Both	Vac	Both	Vac	Vac
Time in unit (min)*	90	60	30	40	60	60	60	45
Time in transit (min)**	1	2	1	10	15	30	10	10
Total time	91	62	30	50	75	90	70	55
Transport method***	Porter	Porter	Auto	Porter	Porter	Porter	Porter	Porter
Dialysate bicarb	35	35	35	35	40	35	35	35
% ×2/week	5	15	12	9	2	3	11	2
% neck line	60	15	25	30	15	10	10	40
Median URR	70	62	70	68	76	76	70	68
Sample interval****	Long	Short	Short	Long	Short	Long	Short	Long

*Time in unit: Approximate time (in minutes) sample remains in the renal unit after collection, before being picked up for transport to laboratory

**Time in transit: Time (in minutes) to reach lab after being picked up from dialysis unit

***Transport method: Auto = automated sample transfer method to lab

****Sample interval: Short = Wednesday or Thursday, Long = Monday or Tuesday

Discussion

The median serum bicarbonate value reflects the control of metabolic acidosis by a centre and methodological issues could confound the interpretation of the serum bicarbonate data. This may have clinical relevance since true metabolic acidosis is a catabolic state. Recently it has also been suggested that alkalosis after haemodialysis, increases the rate of vascular calcification.

This study was unable to demonstrate specific methodological reasons for the variability in serum bicarbonate between renal units. Although the number of patients on twice a week dialysis was different between the two groups, it is not possible for the small number of these patients to affect the median bicarbonate value to such a degree.

In particular, it might have been expected that time delays in specimen transportation would explain the differences in bicarbonate. This has not been shown, although it is accepted that the time intervals were a crude estimate reported by nurses which may be inaccurate and that the Registry has not accounted for delays in processing the blood sample once it had reached the laboratory.

The Registry data aggregates the HD satellite unit data with the in-centre data and this may be a confounder in the analysis. There are considerable limitations to the interpretation of a small telephone survey and the numbers of centres in the study were small.

It has been shown that different laboratory assays produce different bicarbonate results[2]. This has not been investigated in this study although it would also be of interest.

References

1. Kirschbaum B. Spurious metabolic acidosis in hemodialysis patients, *Am J Kidney Dis* 35:1068–1071.
2. Bray *et al.* The magnitude of metabolic acidosis is dependent on difference in bicarbonate assays, *Am J Kidney Dis* 1996 Nov;28(5):700–3.