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ORIGINAL ARTICLE

Positive trends in paediatric renal biopsy service provision in the UK: a national survey and re-audit of paediatric renal biopsy practice

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Abstract
Background Paediatric renal biopsy standards introduced in the UK in 2010 were intended to reduce variation and improve practice. A concurrent national drive was aimed at building robust paediatric nephrology networks to ensure services cater for the needs of the family and minimise time away from home. We aimed to identify current national practice since these changes on behalf of the British Association for Paediatric Nephrology.
Methods All UK paediatric nephrology centres were invited to complete a survey of their biopsy practice, including advance preparation. From 1 January to 30 June 2012, a national prospective audit of renal biopsies was undertaken at participating centres comparing practice with the British Association for Paediatric Nephrology (BAPN) standards and audit results from 2005.
Results Survey results from 11 centres demonstrated increased use of pre-procedure information leaflets (63.6 % vs 45.5 %, P=0.39) and play preparation (90.9 % vs 9.1 %, P=0.0001). Audit of 331 biopsies showed a move towards day-case procedures (49.5 % vs 32.9 %, P=0.17) and reduced major complications (4.5 % vs 10.4 %, P=0.002). Biopsies with 18-gauge needles had significantly higher mean pass rates (3.2 vs 2.3, P=0.0008) and major complications (15.3 % vs 3.3 %, P=0.0015) compared with 16-gauge needles.
Conclusions Percutaneous renal biopsy remains a safe procedure in children, thus improving family-centered service provision in the UK.

Keywords Paediatric · Renal biopsy · Complications · UK National Standards

Introduction

Renal biopsies are an important diagnostic procedure in paediatric nephrology. British Association for Paediatric

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Nephrology (BAPN) standards for renal biopsies in children have been in place since a national report highlighted a large variation in biopsy procedures across the UK [1]. Despite this variation, good outcomes in terms of obtaining a diagnosis were achieved in 97.5 % of cases. Biopsies under sedation were found to be just as successful as those carried out under general anaesthetic (GA) with regard to sample adequacy and rate of diagnosis, with no increase in complication rate [1]. In addition, it is well established that day-case procedures can provide cost savings and minimise impact on patients' families [2, 3]. In 2010 only one third of biopsies were being performed as day-case procedures in the UK [1]. Furthermore, the report noted that only half the centres were providing information to patients and their families regarding the biopsy procedure, and only a minority employed play preparation on the day of the biopsy.

This study was undertaken to review any changes in paediatric renal biopsy practice over the last 7 years. We repeated the national survey and carried out a further prospective audit of all biopsies carried out over a 6-month period, comparing findings with published BAPN standards [1].

Methods

A preliminary survey was sent to all 14 centres performing renal biopsies on children, with the objective of identifying current routine practice. In addition to standard technical questions, we requested specific information relating to the procedure and preparation (ESM Appendix 1). A prospective audit of all paediatric renal biopsies was undertaken at participating centres between 1 January 2012 and 30 June 2012. Local teams at participating centres were requested to collect data prospectively (at that time or within 24 h of the procedure) on data-capture sheets. Data collection comprised demographic characteristics, indication for biopsy, type of sedation or anaesthetic used, whether the procedure was performed as a day case, operator experience (trainee or consultant), sample adequacy and final histological diagnosis. Complication details included macroscopic haematuria (with and without clot retention; requirement for blood transfusion), oxygen requirement and post-procedural pain and its treatment. Late complications were defined as those recorded following discharge and details of any readmissions. Biopsies were audited against BAPN standards, as follows:

- All patients should receive appropriate written information about the biopsy procedure.
- For both native and transplant biopsies three or fewer passes should be achieved on 80 % of occasions.
- There should be adequate tissue for diagnosis on 95 % of occasions.
- Major complications (defined as delay in patient discharge as a result of post-biopsy complications or requirement for further investigations, intervention or monitoring as a result of a biopsy) should be <5 %.

Results were compared with the 2005 national paediatric renal biopsy audit [1].

Of note, since the last renal biopsy audit, the standard number for needle passes has increased to three or fewer for transplant biopsies, bringing it in line with the Banff 97 criteria [4]. In addition, the definition of major complications was changed since the last audit. It is now defined as delay in patient discharge as a result of post-biopsy complications or requirement for further investigations, intervention or monitoring as a result of a biopsy. This would still include complications classified as major from the previous definition, which defined a major complication as one that caused macroscopic haematuria, requirement for blood transfusion and/or surgical exploration, delay in discharge or readmission for observation.

Statistics

All data were entered onto a database and analysed using Microsoft Excel. Categorical data were analysed with the chi-square test using a significance level of $P<0.05$.

Results

A total of 331 biopsies were evaluated. Eleven of the 14 invited centres participated in the survey regarding their biopsy process, and 12 centres provided data for the audit (Fig. 1).

All biopsies performed during the study period were included in the analysis. Though not all data items were complete for every biopsy episode, data for the key issue of complications was complete for all 331 biopsies. Data was incomplete for type of sedation (n=41), admission (n=5), operator (n=24) and number of passes (n=37). Missing information was seen across all centres in similar proportions. The audit period was reduced from 6 to 12 mo, resulting in fewer biopsies in comparison to data obtained in 2005. Biopsies carried

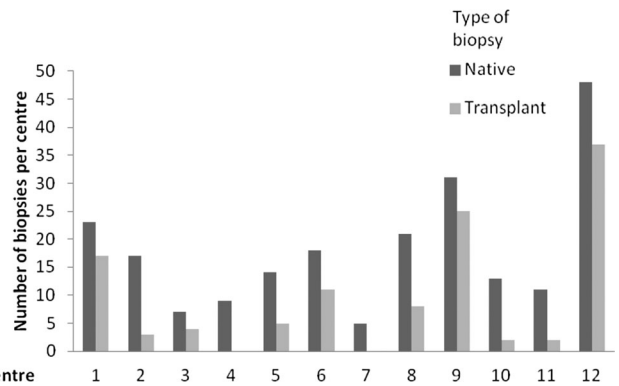

Fig. 1 Numbers of native and transplant biopsies carried out by each of 14 UK centres over a 6-month period

out as routine post-transplant protocol or for suspected malignancy were not included (n=11).

Preliminary survey

Preliminary questionnaires regarding standard renal biopsy practice were returned by 11 centres; ten of these centres participated in the same survey in 2005 [1]. Results of this survey show an increase in the use of pre-procedure information for patients and families, employment of play preparation and biopsies being done as day-case procedures, as reported in Table 1.

Standard practice for the number of cores routinely taken is two (range 1–3) for native and two (range 1–2) for transplant biopsies. Biopsy equipment varied across centres. Seven centres use Cook quick-core, spring-loaded Tru-core or Angiotech Tru-core needles. The four remaining centres use other, unspecified, needle types. Most centres use 16-gauge needles (7), with some centres using 14 gauge (2) and 18 gauge (2). Same-day histology results are available in nine centres, of which five have a histopathology technician in attendance at the time of biopsy. Data was unavailable for two centres.

Table 1 Survey results of renal biopsy practice from 11 paediatric nephrology centres across the UK comparing data from 2005 to 2012

Survey results	2005 data		2012 data	
	Number of centres	Percent	Number of centres	Precent
Use of Information leaflet	5	45.5	7	63.6
Use of Play preparation anddistraction	1	9.1	10	90.9
Elective biopsies performed as day case	6	54.5	9	81.8
Routine IV fluids	4	36.4	3	27.3
Sedation				
General anaesthetic as routine	6	54.5	4	36.4
IV sedation as routine	5	45.5	2	18.2
Both IV sedation and general anaesthetic as routine judged by patients age	2	18.2	5	45.5
Inhaled Entonox® and local anaesthetic	1	9.0	1	9.0
Operator				
Nephrologist alone	4	36.4	6	54.5
Radiologist alone	2	18.2	2	18.2
Combination of nephrologists and radiologists	5	45.5	3	27.3
Imaging and biopsy site marking				
Real-time ultrasound	8	72.7	10	90.9
Premark site with ultrasound localisation	2	18.2	1	9.1

Prospective audit of renal biopsies

Twelve centres participated in the audit: ten of these centres submitted data for the same audit in 2005 [1]. Initial demographic data, biopsy type, operator and admission details are summarised in Table 2.

A total of 186 biopsies were performed in theatre under GA; 81 biopsies under IV sedation required continuous monitoring. The remainder, using Entonox® alone (n=17) or no sedation (n=9), required regular observation. Data was missing for 41 cases. Details regarding place of procedure, such as nephrology or radiology units or operating theatre, as well as exact duration of the procedure, were not collected. All tissue samples were obtained using percutaneous biopsy; none required surgical (open) biopsy. In 2010, the most common indication for native biopsy was nephrotic syndrome. Further details can be found in ESM

Table 2 Comparison of data obtained in 2005 and 2012 detailing patient demographics, type of biopsy, operator, type of admission and sedation used. Note that the 2005 audit was carried out over 12 months and 2012 audit over 6 months

	2005 (n=531)	2012 (n=331)
Demographic data		
Median age (range)	11.8 years (0.08–18.9)	10 years (0.33–19)
Median weight (range)	39.3 kg (3.4–125)	33 kg (6.4–97.5)
Biopsy		
Native	65.6 %	66.3 %
Transplant	34.4 %	33.7 %
Operator		
Nephrologist	69 %	61.8 %
Radiologist	29 %	28 %
Combination	–	3 %
Trainee	39 %	20.2 %
Data missing	–	7.3 %
Admissions		
Day case	34 %	49.5 %
Inpatient for renal biopsy	42 %	29.3 %
Inpatient for other reason	24 %	19.6 %
Missing data	–	1.5 %
Type of sedation	–	
General anaesthetic	61 %	56.2 %
IV sedation	30.1 %	23.9 %
Entonox®	–	5.1 %
IV sedation and Entonox®	–	1.8 %
Missing data	–	12.4 %

Table 3 Native biopsy diagnoses

Diagnosis	Number	Percentage
Minimal-change nephrotic syndrome	33	15.2
Henoch Schönlein purpura nephritis	33	15.2
Focal segmental glomerulosclerosis	26	11.9
Immunoglobulin A nephropathy	22	10.1
Malignancy	17[a]	7.8
Systemic lupus erythematosus	15	6.9
Acute postinfectious glomerulonephritis	9	4.1
Acute interstitial nephritis	7	3.2
Membranoproliferative glomerulonephritis	7	3.2
Membranous nephropathy	5	2.3
Thin basement membrane	5	2.3
Chronic kidney disease	4	1.8
Alport syndrome	3	1.4
Acute tubular necrosis	3	1.3
Drug toxicity	2	0.9
Pauci-immune glomerulonephritis	2	0.9
Pyelonephritis	1	0.5
Congenital nephrotic syndrome	1	0.5
Normal	10	4.1
Other	5[b]	2.3
No definitive diagnosis	6	2.8
Missing information	1	0.5
Total	217	

[a] Oncological diagnoses comprise Wilms' tumour (11), malignant rhabdoid tumour (2), sarcoma (1), acute lymphoblastic leukaemia (1), neuroblastoma (1), renal cell carcinoma (1)

[b] Other diagnoses are made up of polyarteritis nodosa (1), likely haemolytic uremic syndrome (1), karyomegalic-like nephropathy (1), collagen deposits in mesangium and basement membrane (suspected nail–patella syndrome) (1), C1q nephropathy/basement membrane nephropathy (1)

Appendix 2. The most common diagnoses for native biopsies were minimal-change nephrotic syndrome and Henoch Schönlein purpura (HSP) nephritis (Table 3).

For transplant biopsies (n=114), the most common diagnoses were interstitial fibrosis and tubular atrophy not otherwise specified (IFTA-NOS) (22.8 %) and acute cell-mediated rejection (14.9 %). Drug toxicity was confirmed in 13 biopsies performed due to graft dysfunction.

Audit against agreed standards

Number of needle passes

The standard set for the number of needle passes required to obtain sufficient tissue is less than or equal to three passes in at least 80 % of native or transplant biopsies. This was achieved in ten of 12 centres for native and nine of ten centres for transplant biopsies (Fig. 2). Despite this data, diagnoses were made in 97.9 % of cases, with the majority of tissue obtained in two passes.

For native biopsies, the mean number of passes was three [median 2, interquartile range (IQR) 2–3, range 1–11]. Sufficient tissue to make a diagnosis was obtained in three or fewer passes in 86.2 % (n=187) and in two or fewer passes in 60.3 % (n=131) of cases. The majority of tissue was obtained in two passes (57.6 %, n=125), and a small minority required more than three passes (2.8 %, n=6). For transplant biopsies, the mean number of passes was two (median 2, IQR 2-2.5, range 1–5). Sufficient tissue was obtained in three or fewer passes in 88.4 % (n=100) cases, with the majority requiring two passes (48.6 %, n=55) and a minority requiring more than three (3.5 %, n=4). Data on number of passes was missing for 27 native and nine transplant biopsies and therefore not included in the final analysis.

Sample adequacy

For the purposes of this audit, an adequate sample was defined as one containing ten or more glomeruli; however, in cases with fewer glomeruli, a sample could still be classified as adequate if a diagnosis could be reported by a histopathologist. A diagnosis was achieved in 324 of 331 (97.9 %) cases by a histopathologist, despite 46 cases having less than ten glomeruli. Diagnoses could not be made in five of 46 (10.9 %) biopsies with fewer than ten glomeruli compared with four of 285 (1.4 %) cases that had ten or more glomeruli. In native and transplant biopsies, similar rates of obtaining adequate samples (≥10 glomeruli) were observed, whether two or three passes were taken (84.3 % vs 85.4 %), with no statistically significant difference (P=0.48).

Complications

Major complications were reported in 4.5 % of cases (n=15). This was a 50 % reduction from the major complication rate seen in the 2005 audit (10.4 %). The BAPN standard for major biopsy-related complications is <5 % of total biopsies, which was achieved by six of the 12 centres. Four centres had no complications and carried out between five and 29 biopsies in total over the 6-month period. The remaining six centres had major complication rates of 5–20 % (Table 4).

There were no biopsy-related nephrectomies or fatalities and no requirement for surgical or radiological intervention.

Macroscopic haematuria accounted for 12 of the 15 cases classed as major complications. These patients ranged from 5 to 19 (median 9.7) years. Of these 12 cases, ten were identified prior to discharge and two presented after 24 h. Three patients with macroscopic haematuria developed clot retention, and one needed a blood transfusion. Final histological diagnoses for these patients included minimal-change disease (3), Henoch Schönlein purpura nephritis class III (2), membranous

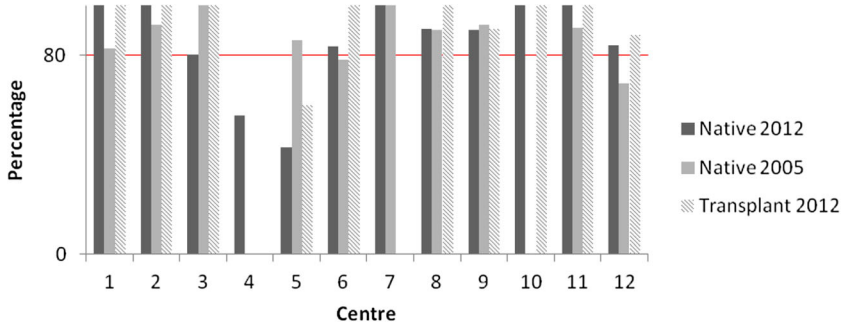

Fig. 2 Comparison of centre performance against standards for three or fewer passes in native and transplant kidneys, which should be achieved on 80 % of occasions, as indicated in the graph. Note the standard for number of passes in transplant kidneys was changed after 2005; therefore, there is no comparison data. Data on number of passes was missing for 27 native and nine transplant biopsies.

nephropathy (1), primary focal segmental glomerulosclerosis (1), membranoproliferative glomerulonephritis (1), lupus nephritis (1), IFTA-NOS with chronic drug toxicity (1), cell-mediated rejection (1) and normal kidney (1). The remaining three major complications were due to delayed discharge owing to recovery from GA (0.3 %, n=1), post-procedure nausea, pain and vasovagal episode (0.3 %, n=1) and following a biopsy done late in the day requiring observation overnight (0.3 %, n=1).

Minor complications included pain following the biopsy, requiring extra analgesia (0.6 %, n=2) and an oxygen requirement (1.2 %, n=4). Oxygen was required in cases using IV sedation (0.6 %, n=2) as well as under GA (0.6 %, n=2). The time scale for supplemental oxygen requirement was specified as being during the procedure (0.3 %, n=1) and within 30 min of biopsy (0.9 %, n=3). There was no significant difference in overall complication rate between nephrologists compared with radiologists at the consultant (P=0.056) and trainee (P=0.15) level or between consultants and trainees (P=0.93). Of the 15 cases with major complications, one biopsy was undertaken without sedation or anaesthesia, three using IV sedation and the rest under GA. There was no significant difference in major complications (P=0.48) or overall complication rate (P=0.89) whether GA or IV sedation was used.

Major complications occurred in 2.6 % of cases using a 14-gauge needle (n=38), 3.3 % using a 16-gauge needle (n=239) and 15.3 % using an 18-gauge needle (n=39). There were significantly more complications associated with the 18-gauge compared with the16-gauge (P=0.0015) needle. The median number of passes using the 18-gauge needle (median 3, IQR 2–4, range 1–11) was significantly higher than both the 16-gauge (median 2, IQR 2–3, range 1–5, P=0.0008) and the 14-gauge (median 2, IQR 2–2.3, range 1–5, P=0.007) needles. Despite this finding, there was no significant difference in complication rates according to number of passes taken.

Table 4 Number of patients with macroscopic haematuria, delayed discharge or readmission following renal biopsy in comparison to 2005. (–) denotes sections where data is not available

Centre	Number of patients with a major complication	Number of biopsies	Percentage of patients per centre with a major complication (2012)	Percentage of patients per centre with a major complication (2005)
1	2	40	5.0	27.8
2	4	20	20.0	0
3	0	11	0	14.3
4	1	9	11.1	–
5	2	19	10.5	30.8
6	2	29	6.8	7.9
7	0	5	0	0
8	0	29	0	7.4
9	2	56	3.6	8.8
10	0	15	0	–
11	1	13	7.7	25
12	1	85	1.2	2.7
Total	15	331	4.5	10.4

Discussion

This national survey and audit identified progress made over the last 7 years towards meeting the BAPN standards for paediatric renal biopsies. It also confirms that this is a safe procedure. Key findings include a significant increase in the use of play preparation and biopsies undertaken as day-case procedures, with no increase in complication rates associated with the latter change. Pre-procedure information is being used by an increasing number of centres compared with 2005, but four centres still do not make use of it. Sedation for biopsies is being tailored to individual patient needs. Sample adequacy rates remain more than 95 % and, reassuringly, major complication rates have dropped markedly with over half of UK paediatric centres now achieving standards in line with BAPN recommendations.

Current Royal College of Paediatrics and Child Health recommendations for creating robust paediatric nephrology networks raises the importance of family-centred care [5]. Results from our national survey highlight a trend towards meeting this objective, with an increase in uptake of day-case biopsy procedures enabling families to spend less time away from home. Timing of complications and whether they caused delay in discharge or readmission were recorded as part of this multicentre audit. This information reinforced the safety of carrying out the procedure as a day case. Our data shows that 82 % of paediatric nephrology centres in the UK perform renal biopsy as a day-case procedure. This is in line with recent data showing no significant increase in complication rate, or missed complications, following day-case procedures [6–8]. Practices outside the UK remain variable. A national survey across 74 nephrology centres in France [9], showed that the majority prefer to observe patients for at least 24 hours following biopsy (84.5 % for 24 h; 3.6 % for >24 h; 2.2 % for 8–12 h). This may be due to the larger geographical area that paediatric nephrology units in France cover and the consequential travel time required for patients, making it difficult to offer day-case services.

Our survey highlights an improvement in the way patients and their families are informed and prepared for their procedure with the use of written information and play preparation. The benefit of good preparation and play therapy for invasive procedures is well known and used across a variety of specialities in paediatrics, both within and outside the UK [10–18]. However, use of pre-procedure written information, though improved, is still not universal. Survey data from French nephrology units showed written and verbal information for renal biopsy is given in 55.7 % of centres, with 20.5 % being given written information alone, 21.6 % verbal information alone and 2.2 % no information [9]. This is comparable with our data showing 63.6 % of centres give written as well as verbal information. As yet, there is no published data on use of play therapy in renal biopsy outside of the UK. Finally, there seems to be a transition away from rigid sedation or anaesthetic protocols to regimes that aim to meet the needs of the patient, taking into account their age and comprehension. More centres now aim to employ IV sedation compared with the 2005 survey information. Despite this, audit data shows that the actual proportion of biopsies done with IV sedation has not changed since the last audit. Perhaps this is because GA is still preferred in younger patients. Some centres use GA as part of their routine protocol for younger patients. It would be useful to investigate this further to determine how decisions are made concerning sedation and anaesthesia. The use of Entonox® with local anaesthetic is a viable option for sedation in older, cooperative patients. Survey results show that one centre offers this as the first line and uses GA where Entonox® cannot be used. Audit data shows a quarter of participating centres use Entonox® for sedation in older, cooperative patients. However, the actual number of biopsies using Entonox® comprised only 5.1 % (n=17). As services are moving towards family-centred care, feedback from patients and their families is paramount and could be collected as part of future audits in order to help develop services further.

Nephrologists continue to undertake the majority of biopsies (61.8 %), with the remainder carried out by radiologists. This ratio remained similar to that in 2005. The decision for biopsies to be carried out by either specialist is centre specific and to our knowledge not based on age. At three centres, both radiologists and nephrologists simultaneously perform biopsies, which may be because radiologists provide the ultrasound scan and nephrologists perform the biopsy. The number of centres using a combination of both specialities fell from five in 2005 [1]. Audit data showed that in 2012, biopsies by a combination of radiologists and nephrologists dropped to 3 % (n=10). A significant reduction in biopsies by trainees was noted, which almost halved in comparison with 2005 data. Data was not collected for the number of trainees in post at the time of this or the previous audit, which may be something to take into consideration in the future to accurately determine trainee exposure to learning opportunities.

Data from this audit is informative in enabling centres to compare their practice and complication rates to ensure their performance is in line with their peers. This benchmarking process may be particularly useful for smaller centres that carry out fewer biopsies. Five centres carried out between 5 and 15 biopsies in the 6-month audit period. These centres had low complication rates, which raises the question of whether senior nephrologists feel they have enough opportunities to maintain their technical skills, which is an important part of the UK General Medical Council's revalidation process [19]. Potentially, the use of simulation-based training may be a viable option to circumvent this possibility.

National consensus regarding indications for biopsy within both adult and paediatric populations are known to vary between individual centres [1, 20]. An area of controversy is the use of renal biopsy in cases of isolated microscopic haematuria [21, 22]. Results from observational studies of these patients who underwent the procedure show normal or minor histopathological abnormalities requiring no additional active treatment apart from monitoring, therefore providing an argument that biopsies are potentially unnecessary in these cases [23–25]. Our data supports those results: there were eight native renal biopsies undertaken with isolated microscopic haematuria stated as the indication. Histological diagnoses in these cases were thin-basement-membrane disease (5), membranous nephropathy (1), normal (1) and lupus nephritis (1). Regarding the latter case, additional clinical data, such as systemic symptoms, results of other investigations and patient management were not available. The number of biopsies carried out for isolated microscopic haematuria dropped from 34 (9.1 %) in 2005 to eight (3.7 %) in 2012. Overall, the number of native biopsies with normal

histology also dropped—from 9.2 % in 2005 to 4.6 %. Another area of controversy is renal biopsy in minimal-change disease, one of the most common histological diagnoses for native biopsy in our audit (n=33). and in other published paediatric renal biopsy data [26, 27]. Indications for biopsy in these cases were steroid-resistant nephrotic syndrome (n=14), steroid-sensitive nephrotic syndrome (n=13), nephrotic syndrome with atypical features (5) and glomerulonephritis (1). Clinicians were not asked tto report disease stage at the time of biopsy or whether biopsy results were required in order to begin alternative treatment or to monitor children on potentially nephrotoxic treatment.

Renal biopsy is a relatively safe procedure, with life-threatening complications occurring in less than 0.1 % of cases [28–30]. Other complications classified as major but not life threatening include macroscopic haematuria, requirement for blood transfusion, surgical exploration and delay in discharge or readmission for observation [1]. Our data show such major complication rates have dropped from 10.4 % in 2005 to 4.5 %, achieving the national standard of less than 5 %. Furthermore, of the 15 major complications, three were due to delayed discharge owing to relatively minor issues. Despite this, only six centres managed to achieve this standard, and of them, four had no complications. Four who did not meet the standard had an improved overall complication rates compared with 2005. Studies of renal biopsies in adults have shown major complication rates from 0.8 % to 3.5 %, with large sample sizes of between 623 and 8573 patients [31–37]. The majority of studies in children, however, are smaller, with reported macroscopic complication rates of between 1.8 % and 45 % with sample sizes of 65 to 2045 patients [8, 35–43]. Surgical or radiological interventions were required in 0.8 to 2.2 % of cases [8, 33, 42]; there were no such cases in our audit. Finally, one study reported the death of a patient following biopsy [34]. It is important to note that these results may not be comparable to ours due to differences in methodology, such as retrospective data collection [8, 34], use of manual biopsy needles [34], use of post-biopsy ultrasound to identify complications [8] and using criteria other than the BAPN classification for major complications, such as inclusion of arterovenous fistula [8].

Macroscopic haematuria was the most common major complication, occurring in 12 of our 331 biopsies (3.6 %), with only one of these cases requiring a red blood cell transfusion. These figures are comparable with those obtained from a recent meta-analysis of adult renal biopsies showing an overall macroscopic haematuria rate of 3.5 %, with 0.9 % requiring blood transfusions [44]. In our audit, of the cases of macroscopic haematuria identified within 24 h (n=10), four were observed for 24 h, and in the remainder, symptoms resolved and the patients were discharged before 24 h. It is interesting to note that most macroscopic haematuria following renal biopsy resolves within 6 hours [42, 45–49] . These facts raise the question of whether this particular complication alone, without the association of clot retention or need for blood transfusion, should be classified as major unless it persists beyond 6 hours of biopsy. Other considerations include recording the length of the biopsy procedure in future audits to ascertain whether it correlates with the risk of major complications.

A key finding was that complication rates did not differ according to the number of passes taken. Numerous studies found no link between number of passes and major complication rate in either the adult and paediatric population in relation to percutaneous renal biopsies [37, 44, 48–51]; we found no significant difference in complication rate according to number of passes. Having said this, the majority of studies reported an average pass rate of two to three and did not assess the association of other minor complications, such as post-procedural pain. Major complication rates were significantly higher in biopsies using the smaller, 18-gauge, needle compared with the 16-gauge needle (P=0.0015). This is in line with the Norwegian study based on adult and paediatric renal biopsies from 1988 to 2010, which also found higher rates of macroscopic haematuria when using 18- vs16-gauge needles [37]. Conversely, a large adult meta-analysis using data from adult renal biopsies found higher requirement for red blood cell transfusion in biopsies using the 14-gauge needle but found no significant difference in rates of macroscopic haematuria between 14-, 16- and 18-gauge automated needles [44]. Our data also shows that the number of passes using 18-gauge needles were significantly higher than when 16- or14-gauge needles were used. It therefore may be that the 18-gauge needle required more passes due to inadequate tissue collection, resulting in a higher complication rate, as opposed to the larger-calibre needles. An adequate tissue sample should contain at least ten glomeruli, or a specimen for which a histopathological diagnosis could be made despite there being fewer glomeruli. Despite the majority of tissue being obtained in two or fewer passes, high overall rates of sample adequacy were maintained from 2005 (97.5 %) to 2012 (97.9 %). As expected, tissue samples with fewer than ten glomeruli had a higher proportion of cases in which diagnoses could not be determined (n=5, 10.9 %) compared with those with more than ten glomeruli (n=4, 1.4 %).

Limitations

We acknowledge that data collected for the survey may have been subject to some response bias, although efforts were made during design of the survey questions to reduce this possibility. Nephrology teams at each individual centre were asked to collect data prospectively in the hope that it would reduce the risk of recall bias; however, we cannot be sure that all centres complied with this. In addition, our method of data collection relies on individual centres to accurately report information such as complications and thus raises the possibility

of reporting bias impacting results. As mentioned earlier, there remains variation in practice across different centres in the UK in terms of indication for biopsy—such as proteinuria level—that should be considered when interpreting diagnostic outcome. Centres were contacted to submit any missing data where possible; if it was not possible, missing data were not included in analyses.

Conclusions and recommendations

In conclusion, results from this national survey and re-audit of paediatric renal biopsy practice across the UK shows that renal biopsy is safe, well tolerated and can be performed as a day-case procedure in the majority of cases. Adequacy remains good, and overall, the standard for the number of needle passes has been met. Combined data show that, overall, the major complication rate has improved and meets BAPN standards. There is inter-centre variation between the number of passes and complication rates. Biopsies with an 18-gauge needles required significantly more passes to obtain adequate tissue and had significantly higher complication rates than those with 14- and 16-gauge needles. The standard that written preprocedure information be available for all families with children undergoing renal biopsy has not been met. Following are our recommendations for paediatric renal biopsy:

1. Day-case procedures should be offered, with post-procedural observation for 4–6 h and discharge if the patient has passed clear urine during that period.
2. Isolated macroscopic haematuria should be classed as a complication only if it lasts more than 6 hours and be classified as a minor complication unless there is an associated requirement for blood transfusion or there is clot retention, in which case it should be classed as major.
3. Pre-biopsy written information about the procedure and post-biopsy care should be provided to the patient and family. The BAPN has developed a generic leaflet that can be adapted by all centres (http://www.infokid.org.uk/kidney-biopsy).
4. Feedback from families regarding patient experience and quality of care should be included in future audits.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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