Papers and Originals

Cell and Bacterial Counts in the Urine of Normal Infants and Children

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Unrecognized urinary tract infection in infancy and childhood may have serious long-term effects, and chronic adult pyelonephritis may originate undetected at this time. The accurate diagnosis of urinary tract infection in the infant and child is thus important. It is usually based on assessment of the number of pus cells or bacteria in the urine, or both. In the case of cells, contamination from the urethra and periurethral area can increase the number falsely, and in an alkaline urine the rapid disappearance of cells can result in a falsely low count. With bacteria, contamination may occur from the perineal skin during collection, and multiplication will occur in a urine left standing. Antibiotics or chemotherapeutic agents may invalidate bacterial counts as diagnostic tests.

The object of the present study was to determine the cell and bacterial counts on urine collected from normal children by commonly used methods and to contrast the findings.

Material and Methods

Seven hundred and ten specimens of urine were examined from 553 infants and children aged 0–14 years who were without any suggestion of urinary tract infection and who had not received antibiotics during the previous six weeks (Table I). Most had not had any antibiotic.

The series included normal newborn infants in a maternity unit, medical and surgical inpatients in a paediatric department, and outpatients attending the same department.

Cell counts on the urine were carried out immediately after voiding, a few drops of homogenized urine being introduced into a Fuchs–Rosenthal counting-chamber. Where the identification of leucocytes was difficult one drop of acetic acid was added to a few millilitres of urine before introducing the urine into the counting-chamber, and further evidence of the presence of granular leucocytes was obtained where necessary by staining the sediment with Leishman's stain after centrifugation. In the neonatal period small non-squamous epithelial cells could significantly influence the cell count and were very difficult to differentiate from granular cells. Because of this, leucocytes and small non-squamous epithelial cells were counted together in the first 10 days of life.

For quantitative bacteriological examination a standard 3-mm. loopful of well-shaken unspun urine was plated and counted as described by Urquhart and Gould (1965).

*p*H was determined with wide range indicator papers.

Methods of Urine Collection

Bag Method.—Adhesive plastic bags obtainable commercially were used in the collection of specimens from infants in the 0–10 day and 11 days–2 years age groups (Table I). In some infants the bag was attached without any previous skin cleansing (unprepared bag) and in others the perineum and external genitalia were well washed with sterile water beforehand (prepared bag). Antiseptics were not used. The bags were kept in position until the child passed urine and removed immediately or within a few minutes, the contents being transferred to a sterile wide-mouthed screw-capped universal container. Faecally contaminated urine was, of course, discarded. In a special group of 10 children aged 1–2 years 10 ml. of sterile water was introduced into the bag before it was applied and the bag removed at intervals ranging from 5 to 30 minutes for bacteriological examination of the contents before any urine had been passed into it.

TABLE I.—*Specimens of Urine According to Sex of Patients, Age Groups, and Method of Collection*

	0–10 Days		11 Days–2 Years		2+–14 Years		0–14 Years
	M	F	M	F	M	F	
No. of patients	95	89	80	79	110	100	553
Unprepared bag ..	38	30	24	24	—	—	116
Prepared bag	33	26	18	27	—	—	104
Total bag	71	56	42	51	—	—	220
Unprepared M.S.U. ..	25	20	42	37	67	68	259
Prepared M.S.U. ..	23	20	20	28	66	74	231
Total M.S.U.	48	40	62	65	133	142	490
Total bag and M.S.U. ..	119	96	104	116	133	142	710

Midstream Urines (M.S.U.s) or "Clean Catch" Specimens.—Midstream specimens were collected from patients in the 0–10 days, 11 days–2 years, and 2+–14 years age groups. The patients in these groups were further divided into those in whom no previous skin preparation had been carried out (unprepared M.S.U.) and those in whom previous to collection the perineum and external genitalia had been well washed with sterile water (prepared M.S.U.) (Table I). So far as was possible all specimens were caught in mid-air after allowing the initial few millilitres of urine to pass uncollected. With boys there was no serious difficulty, but there was with girls. When female infants void, the urine often wells up, forming a lake in the vulva and perineum. Sometimes the urine will be passed as a spray or drip off the posterior perineum. A strong jet may pass obliquely, striking the inner aspect of the thigh. Proper collection requires patience and time, but even with these, perfect collection is often not possible and in some cases specimens could not be obtained without bringing the mouth of the sterile container into contact with the skin. This was thought preferable to allowing the urine to flow over the

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perineal skin before collection. Young girls are often unable to pass urine on demand, and, particularly after any cleansing procedure, an hour or more may elapse before they will do so. Embarrassment commonly appears to be the dominant cause. Thus in the female infant and child many factors militate against the avoidance of contamination in the collection procedure.

Comparison of Methods of Collection on Same Patient

In 28 patients (11 males, 17 females) in the 0–2 year age group an unprepared bag specimen of urine was collected and then from the same patient on the same or following day a prepared specimen. In a further 58 cases (28 males, 30 females) in the same age group a bag specimen was collected followed on the same or the next day by a midstream specimen. In 33 patients (13 males, 20 females) in the 2+–14 year age group an unprepared M.S.U. was collected followed on the same or on the next day by a prepared M.S.U.

Bacterial Flora of Anterior Urethral Area

In 30 patients ranging from 0 to 14 years the anterior urethra was swabbed just before urine collection. Any organism isolated was considered in conjunction with any isolate from the urine specimen. Only organisms potentially pathogenic to the urinary tract were considered—namely, *Escherichia coli,* non-lactose fermenting coliforms, *Proteus, Streptococcus faecalis, Klebsiella, Pseudomonas pyocyanea,* and *Staphylococcus aureus.*

Results

Cell Counts

First 10 Days of Life.—Cell counts from 215 infants are shown in Tables II and III. In males some counts showed a moderate increase above 10 cells/cu. mm. for the first three days but thereafter fell well below this figure. In females the position was different. Throughout the 10-day period the counts tended to be high, 21% being above 10 cells/cu. mm. and 11% above 50 cells/cu. mm. The incidence of raised cell counts was higher in bag than in midstream urines. In bag urines from 56 females 27% were over 10/cu. mm., including 18% over 50/cu. mm. The corresponding figures for 40 M.S.U.s were 13% (P of difference=0.08) and 3% (P=0.01). In bag urines from 71 males 6% showed counts of over 10/cu. mm., including 4% of over 50/cu. mm. None of the cell counts for 48 male M.S.U.s was above 10/cu. mm. (P=0.03 and 0.08).

TABLE II.—*Cell and Bacterial Counts (Potentially Pathogenic Organisms) on 215 Specimens of Urine During the First 10 Days of Life (127 Bag; 88 M.S.U.)*

Day	Sex	No.	Range of Cell Count	Cell Count >10/cu. mm.		Cell Count >50/cu. mm.		Bact. Count 10^5 or Over /ml.	
				No.	%	No.	%	No.	%
1	M	19	0–136	2	11	1	5	3	16
	F	15	0–100	2	13	1	7	5	33
2	M	14	0–150	1	7	1	7	5	36
	F	27	0–250	5	19	2	7	9	33
3	M	18	0–15	1	6	0	0	6	33
	F	19	0–1,000	5	26	4	21	9	47
4	M	19	0–10	0	0	0	0	7	37
	F	14	0–150	4	29	2	14	5	36
5	M	15	0–1	0	0	0	0	8	53
	F	7	0–300	1	17	1	17	4	57
6	M	13	0	0	0	0	0	8	62
	F	3	0	0	0	0	0	2	67
7	M	5	0–2	0	0	0	0	3	60
	F	5	0–42	1	20	0	0	4	80
8	M	5	0–2	0	0	0	0	3	60
	F	1	0	0	0	0	0	1	100
9	M	2	0	0	0	0	0	1	50
	F	1	25	1	100	0	0	1	100
10	M	9	0–2	0	0	0	0	3	33
	F	4	0–125	1	25	1	25	3	75
0–10 days	M	119	0–150	4	3	2	2	47	40
	F	96	0–1,000	20	21	11	11	43	45

TABLE III.—*215 Specimens (119 Male, 96 Female) First 10 Days of Life. 127 Bag Specimens (B) and 88 Midstream Specimens (MS)*

Cells/cu. mm.	Bacterial Count—Potentially Pathogenic Organisms/ml.												
	N.G.		10^3		10^4		10^5		10^6		10^7		
	M	F	M	F	M	F	M	F	M	F	M	F	
201–1,000						1		3		2			B
													MS
151–200													B
													MS
101–150						1		1	2	1			B
													MS
51–100								1					B
								1					MS
11–50		1			1	3		1	1				B
		2				1		1					MS
0–10	18	10	12	2	7	8	22	9	6	7	2	5	B
	18	9	5	7	13	6	12	12		1			MS

		Male	Female
Cell count >10/cu. mm.	Bag urines	6%	27%
	M.S.U.	0%	13%
Bacterial count >10^4/ml.	Bag urines	47%	54%
	M.S.U.	25%	38%

11 Days to 2 Years.—From 104 males none of the cell counts in urine collected either by bag or midstream specimen was above 5/cu. mm. Cell counts in the 116 females were higher. With 51 bag urines 24% exceeded 10 cells/cu. mm., including 6% above 50/cu. mm., while with the 65 M.S.U.s the corresponding counts were 5% (P=0.01) and nil (P=0.07) (Table IV).

2+ to 14 Years.—Only two of the cell counts in the 133 males (all M.S.U.s) exceeded 5/cu. mm., including 1 above

TABLE IV.—*220 Specimens (104 Male, 116 Female) 11 Days–2 Years. 93 Bag Specimens (B) and 127 Midstream Specimens (MS)*

Cells/cu. mm.	Bacterial Count—Potentially Pathogenic Organisms/ml.												
	N.G.		10^3		10^4		10^5		10^6		10^7		
	M	F	M	F	M	F	M	F	M	F	M	F	
201–1,000										1			B
													MS
151–200													B
													MS
101–150													B
													MS
51–100				1				1					B
													MS
11–50		3						5		1			B
		2		1		1							MS
0–10	6	5	5	5	12	11	16	15	2	3	1		B
	18	11	14	12	7	15	21	20	2	3			MS

		Male	Female
Cell count >10/cu.mm.	Bag urines	0%	24%
	M.S.U.	0%	5%
Bacterial count >10^4/ml.	Bag urines	45%	51%
	M.S.U.	37%	35%

TABLE V.—*275 Specimens (133 Male, 142 Female) 2+–14 Years. All Midstream Specimens*

Cells/cu. mm.	Bacterial Count—Potentially Pathogenic Organisms/ml.											
	N.G.		10^3		10^4		10^5		10^6		10^7	
	M	F	M	F	M	F	M	F	M	F	M	F
201–1,000		1								2		
151–200										2		
101–150		2				1		1				
51–100						1						
11–50	1	2						2				1
0–10	105	81	11	10	5	12	9	14	2	5		5

	Male	Female
Cell counts >10/cu.mm.	1·5%	11%
Bacterial counts >10^4/ml.	8%	23%

10/cu. mm. Of the 142 females (all M.S.U.s) 11% exceeded 10/cu. mm., including 7% above 50/cu. mm. (Table V).

Bacterial Counts

First 10 Days of Life.—The incidence of bacterial counts for potentially pathogenic organisms in 215 specimens is shown in Tables II and III and contrasted in the former with the corresponding cell counts. The incidence of counts of 10^5/ml. or over was high (40% male and 45% female) and unlike cell counts showed no significant sex difference. The overall incidence of 50% in 127 bag urines was higher than the 31% in 88 M.S.U.s ($P<0.01$).

First 2 Years of Life.—Apart from the comparison with cell counts in the first 10 days of life, bacterial counts in the first 10 days and in the remainder of the first two years need not be considered separately. There was no significant difference between them at these two periods. Table VI thus shows bacterial counts for potentially pathogenic organisms for the whole of the first two years divided according to sex and method of collection. There was no significant sex difference in either bag urines or M.S.U.s. The incidence of bacterial counts of 10^5 or over/ml. was high, 49% for 108 bag urines and 34% for 73 M.S.U.s—a statistically significant difference ($P=0.001$). At 10^6 or over/ml. the incidences were 15% for bag urines and 3% for M.S.U.s ($P=0.03$) and at 10^7/ml. 4% and nil ($P=0.001$). In the 58 cases in which a bag specimen was followed by an M.S.U. 66% showed a lower bacterial count with the M.S.U. (average difference $=10^2$ organisms/ml.), 15% a lower count with the bag (average difference $=10^2$/ml.), and 19% similar. This is a significant difference ($P<0.00001$). The effect of the time interval between the application of the bag and the voiding of urine into it is shown in Table VII. Longer intervals made little difference, suggesting that contamination was already pronounced at less than half an hour. Where, in 10 children, bags containing sterile water were applied for periods of 5, 15, and 30 minutes all specimens of water produced a pure growth of *E. coli*, the average count at 5 and 15 minutes being 10^5 and at 30 minutes 10^6.

TABLE VI.—*Bacterial Counts (Potentially Pathogenic Organisms) per ml. on 710 Specimens of Urine from Children Aged 0–14 Years*

			No. of Specimens	No Growth		10^1–10^4		10^5 or Over		10^6 or Over		10^7 or Over	
				No.	%	No.	%	No.	%	No.	%	No.	%
0–2 years	Bag	M	113	24	21	37	33	52	46	14	12	3	4
		F	107	19	18	32	30	56	52	20	19	5	5
		Total	220	43	20	69	31	108	49	34	15	8	4
	M.S.U.	M	110	36	33	39	35	35	32	2	2	0	0
		F	105	24	23	43	41	38	37	4	4	0	0
		Total	215	60	28	82	38	73	34	6	3	0	0
2+–14 years	M.S.U.	M	133	106	80	16	12	11	8	2	2	0	0
		F	142	86	61	24	17	32	23	15	11	6	4
		Total	275	192	70	40	15	43	16	17	6	6	

TABLE VII.—*Effect of Time Interval (Application of Bag to Passage of Urine) on Bacterial Count (All Organisms) (219 Children Aged 0–2 Years)*

	< ½ Hour	½–1 Hour	1–2 Hours	> 2 Hours
No.	82	52	43	42
No. 10^6 or over	53 (65%)	28 (54%)	26 (61%)	30 (72%)

2+ to 14 Years.—The incidences of raised bacterial counts in 275 specimens are shown in Tables V and VI. Counts of 10^5 or over/ml. were significantly less frequent than in the 0–2 year group, 16% compared with 34% ($P<0.00001$), and the incidence of specimens in which there was no growth was significantly greater, 70% compared with 28% ($P<0.00001$). Paradoxically the incidence of bacterial counts of 10^6 or more/ml. was significantly higher in females in this group than in M.S.U.s in the 0–2 year group. There was a significant sex difference within the group, 23% of females showing counts of 10^5 or higher/ml. compared with 8% of males ($P=0.001$).

Effect of Preparation on Bacterial Counts

Table VIII shows that with bag specimens in the 0–2 year group skin preparation with sterile water resulted in a significantly higher incidence of bacterial counts of 10^5 or over, 65% compared with 34% ($P=0.0001$). This applied to both sexes.

In the 28 cases in the 0–2 year group in which in the same patient a bag urine was collected without, and then with, previous preparation, the former showed a lower count in 46% of specimens (average difference $=10^3$ organisms/ml.) and the latter in 14% of specimens (average difference $=10^2$ organisms/ml.). This difference is significant ($P<0.01$) and was seen in both male and female children.

With M.S.U.s similar bacterial counts were obtained from unprepared and prepared specimens in the 0–2 year and 2+–14 year groups though at lower incidences in the latter. The similarity was evident in both sexes.

TABLE VIII.—*Effect on Bacterial Count (Potentially Pathogenic Organisms per ml.) of Previous Preparation*

			No.	No Growth		10^5 or Over		10^6 or Over		10^7 or Over	
				No.	%	No.	%	No.	%	No.	%
0–2 years	Bag	Unprep.	116	26	22	40	34	12	10	2	2
		Prep.	104	17	16	68	65	22	20	6	6
	M.S.U.	Unprep.	124	42	34	44	36	4	3	0	0
		Prep.	91	18	20	29	32	2	2	0	0
2+–14 years	M.S.U.	Unprep.	135	95	70	21	15	9	7	4	3
		Prep.	140	97	69	22	16	8	6	2	1

In the 33 cases in the 2+–14 year group in which in the same patient unprepared and then prepared M.S.U.s were examined, 6% of unprepared specimens had lower counts than prepared (average difference $=10^3$ organisms/ml.) and 42% of prepared specimens lower counts than unprepared (average difference $=10^2$ organisms/ml.). This is a significant difference ($P<0.001$).

Thus with bag urines preparation of the type described here before collection resulted in higher bacterial counts, while with M.S.U.s it did not affect or lowered the bacterial count.

Comparisons Between Organisms Isolated from the Anterior Urethra and from Corresponding Specimens of Urine

In 63% of the 30 cases examined similar organisms were cultured from the anterior urethra and from the urine and in 20% of cases different organisms. In 13% of cases the urine was sterile and in 3% no growth was obtained from the anterior

urethral swab. There is thus considerable correlation between bacterial flora found on the anterior urethral area and in the urine.

Organisms Cultured

The frequency with which the various potentially pathogenic organisms occurred was as follows: *E. coli* 60%, *Proteus* 28%, non-lactose fermenting coliforms 9%, *Ps. pyocyanea* and *Strep. faecalis* 1%, *Klebsiella* and *Staphylococcus aureus* less than 1%. Where potentially pathogenic organisms were associated with a bacterial count of 10^5 or more/ml. they were present in pure growth in 42% of cases in the 0–2 year group but in only 12% in the 2+–14 year group.

Correlation Between Cell Counts and Bacterial Counts

In the first 10 days of life the incidence of bacterial counts for potentially pathogenic organisms of 10^5 or over/ml. (42%) was very much higher than the incidence of cell counts of more than 10/cu. mm. (11%) or 50/cu. mm. (6%). For this period Table III shows the combined cell and bacterial counts at various levels. If the upper limit of the normal cell count is set at 50/cu. mm. and of the bacterial count at 10^4/ml. only one M.S.U. (1%) was outside these limits. Of the bag urines 10 (8%) exceeded these limits, and if the upper accepted limit of the bacterial count is raised to 10^5/ml. 5 (4%) did so. With the bag urines it was the females in particular (8 out of 10) who showed high combined counts.

In the 11 days to 2-year period (Table IV) none of the male patients gave specimens which exceeded the combined criteria of 10 cells/cu. mm. and 10^4 bacteria/ml. whether the urine was collected by bag or mid-stream. Nor did any of the female specimens collected as M.S.U.s exceed these limits, but eight of the bag urines in females (16%) did so.

In the 2+–14-year period (Table V) where all specimens were M.S.U.s none of the male specimens exceeded the limits of 10 cells/cu. mm. and 10^4 organisms/ml., but eight specimens from females (6%) lay outside these limits and five (3.5%) exceeded the combined criteria of 10 cells/cu. mm. and 10^5 bacteria/ml.

While there is thus a good deal of variability in the normal cell and bacterial counts in children it is possible from the data presented here to recognize upper limits of normal for cell counts alone, for bacterial counts alone, and for combined cell and bacterial counts for different age groups, and also for different sexes and for different methods of collection. This has been done in Table IX where are represented "diagnostic levels" which generally just exceed these upper normal limits or in a few instances would be reached in less than 6% of normal children.

Discussion

It is important that urinary tract infection in infancy and childhood should be diagnosed early and confidently, yet the symptoms may be far from specific (Burke, 1961 ; Smellie *et al.*, 1964). Definitive diagnosis depends largely on examination of the urine for its cellular and bacterial content. The conditions under which this examination is made must be strictly defined, otherwise false and highly misleading results may be obtained. It is very likely that false-positive diagnoses are occurring to a considerable extent at present and that many children are given unnecessary and even harmful antibiotic treatment. Even more dangerous, particularly in infancy, is the possibility that wrongly presumed urinary tract infection may delay or mask the diagnosis of other more sinister disease. On the other hand, failure to diagnose urinary tract infection when it is present may have serious short-term and long-term effects.

Apart from bag collections over the first three days of life the cell count in the normal male child aged 0–14 years, whether urine is collected by bag or M.S.U., hardly ever exceeds 10/cu. mm. or in the case of M.S.U.s after the age of 11 days 5/cu. mm. Thus in the male infant the urinary cell count is a valuable diagnostic procedure.

In the female the position is less clear cut. Over the first 10 days of life high cell counts may be obtained normally due to the presence in the urine of small round non-squamous epithelial cells which are difficult to differentiate from pus cells on simple counting. Differentiation can usually be made by staining a film of the urinary sediment, but this is time-consuming. James (1959) suggested 50 cells/cu. mm. as the upper limit of normal at this age, but from our results a slightly higher level (75/cu. mm.) would be more appropriate with M.S.U.s and a count of over 300/cu. mm. for bag urines.

In female children aged 11 days to 2 years 24% of bag urines and 5% of M.S.U.s show cell counts in excess of 10/cu. mm. but few exceed 50 cells/cu. mm. At this age 50 cells/cu. mm. in M.S.U.s or double this number in bag urines represent the upper limits of normal. In the 2+–14 year age group in girls the cell count can commonly be high and counts of up to 150/cu. mm. can occur normally.

Midstream specimens are difficult to collect in young children and this has popularized the use of adhesive plastic

TABLE IX.—*Diagnostic Levels in Children Aged 0–14 Years for Cell Counts Alone, Bacterial Counts Alone, and Combined Cell and Bacterial Counts. Urine Collected by Bags and as Midstream Specimens*

Type of Collection	Age	Sex	Cell Count Alone		Bacterial Count Alone		Combined Cell and Bacterial Count	
			Diagnostic Level Cells per cu. mm.	Percentage Chance of Occurrence in Normal Child Ave. ± 2 × S.E.	Diagnostic Level Bacteria per ml.	Percentage Chance of Occurrence in Normal Child Ave. ± 2 × S.E.	Diagnostic Level Cells per cu. mm./ Bact. per ml.	Percentage Chance of Occurrence in Normal Child Ave. ± 2 × S.E.
Mid-stream urines	0–10 days	M	> 10	0	> 10^5	0	> 10/ > 10^4	0
		F	> 75	0	> 10^6	0	> 75/ > 10^4	0
	11 days–2 years	M	> 5	0	> 10^6	0	> 5/ > 10^4	0
		F	> 50	0	> 10^6	0	> 10/ > 10^4	0
	2+ years–14 years	M	> 5	1·5 ± 2·1	> 10^5	1·5 ± 2·1	> 5/ > 10^4	0·8 ± 2·1
		F	> 150	2·1 ± 2·4	> 10^7	2·1 ± 2·4	> 10/ > 10^6 > 150/ > 10^4 or > 50/ > 10^5	0·7 ± 1·4 2·8 ± 2·8
Bag urines	0–10 days	M	1–3 days: > 150	0	> 10^7	0	1–3 days: > 10/ > 10^6 or > 150/10^4	0
			4–10 days: > 10	0			4–10 days: > 10/ > 10^4	0
		F	> 300	1·8 ± 3·6	> 10^7	0	> 10/ > 10^6	0
	11 days–2 years	M	> 10	0	> 10^7	0	> 10/ > 10^4	0
		F	> 100	2·0 ± 3·9	> 10^6	0	> 100/ > 10^4	2·0 ± 3·9

bags. Bag urines, with bacterial counts on them, have been used in determining the incidence of urinary tract infection in childhood (Smellie *et al.*, 1964). Yet in the present study half of the urines collected in this way in normal infants of both sexes aged 0–2 years were found to produce bacterial counts for potentially pathogenic organisms of 10^5/ml. and approximately 15% counts of 10^6/ml. Similar results have been obtained by Lam *et al.* (1967) and Newman *et al.* (1967).

The evidence that bacterial counts on urine voided into a bag within half an hour of the bag being applied are as high as those where the bag has been applied for over two hours before voiding suggests that contamination of the urine takes place at the time that it is passed or of the bag at the time that it is applied. The high bacterial counts in the bags containing sterile water suggest that contact with the genitalia and skin of the perineum results in immediate contamination. Previous cleansing of the skin of the perineum and genitalia with sterile distilled water appeared to increase contamination, possibly by creating a "storm" of bacteria which might otherwise have lain dormant. More extensive irrigation, as practised by Lincoln and Winberg (1964), may reduce contamination.

It has been suggested that when urine is contaminated from the urethra or vulva the bacterial count is unlikely to exceed 10^4/ml., but that where bacteria multiply in the bladder in genuine urinary tract infection they will reach levels of 10^5 or more/ml. (Kass, 1960). This may be true for the adult but is probably not valid for the infant and child, where the volume of urine is very much smaller and the amount of contamination is likely to be relatively very much greater. It is clear that the bacterial count of 10^5/ml., which has attained such significance in the adult, is not valid as a dividing line between infected and non-infected urine in the child. Variations in age and sex, the effect of antiseptics used in skin cleansing, and the technique of collection all have to be considered in assessing results. Adult criteria are often misleading in the child, and criteria determined by one method of collection cannot be transposed to interpret results from another.

The normal limits for the diagnosis of urinary tract infection based on single cell or bacterial counts are wide but can be much more narrowly defined when cell and bacterial counts are considered in combination (Houston, 1963). Where M.S.U.s are collected as described here the combined limits of 10 cells/cu. mm. and 10^4 organisms/ml. which are so commonly used (Stansfeld, 1966) would hardly ever be exceeded in males and would be exceeded in only 4% of females. With bag urines under 3% of males and 16% of females would be outside the same limits, but if in females the combined limits are taken as 50 cells/cu. mm. and 10^5 bacteria/ml. less than 4% would lie outside these.

Urinary tract infection should, if possible, be diagnosed both by cell counts and by bacterial counts, repeating these observations and finding them constant, and finding, too, the same pathogenic organisms in pure growth on both occasions. Ideally a midstream specimen should be a true "clean catch" even if it takes several hours to obtain this. Unfortunately it may be impracticable to implement optimum diagnostic procedures. Treatment may have to be instituted without waiting for second specimens; it may be impossible to obtain a perfect midstream specimen; the very frequency with which urinary tract infection is suspected in children makes simple rapid methods of urine collection for diagnostic purposes obligatory. Under these circumstances it appears worth while to know the limits of single specimen observations, both when only the result of a cell count or a bacterial count is available and when combined observations of cell and bacterial counts have been made on the specimen and can be considered together (Table IX).

With some of the criteria shown in Table IX there will be a small overlap between the findings in the normal child and those in the child with a urinary tract infection. Until absolute methods of diagnosis become possible such overlap is likely in any method of collection of urine passed per urethra. Precise definition of the limits of any method employed will increase its value and point to its limitations.

Summary

Normal cell and bacterial counts in urine obtained both by plastic adhesive bags and as midstream urines from male and female children from birth to 14 years have been determined by a study of 710 specimens obtained from 553 normal children.

At all ages cell counts were significantly higher in female than in male children when urine was collected by bag and as midstream specimens.

Until the age of 2 years bacterial counts were similar in male and in female children, but over the age of 2 years bacterial counts were higher in female children. These similarities and differences were seen in both bag and M.S.U.s.

Cell counts and bacterial counts in both males and females were significantly higher in urine obtained in bags as compared with M.S.U.s.

With midstream specimens previous preparation by washing the genital area with sterile distilled water did not affect the bacterial count up to the age of 2 years but reduced it in children over this age. With bags, previous preparation resulted in higher bacterial counts. There was evidence of rapid and significant contamination of urine collected by bag.

Organisms present on the anterior urethra were commonly the same as those isolated from urine specimens.

The pattern of distribution and upper limits of normal for cell and bacterial counts in male and female infants at various ages for urine collected by bag and as midstream specimens are defined. On the basis of these definitions standards are suggested for individual counts of cells and bacteria and for combined counts (on the same specimen) by which the diagnosis of urinary tract infection in infancy and childhood may be made.

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