ORIGINAL ARTICLE

Cost efficiency analysis of modern cytocentrifugation methods versus liquid based (Cytyc Thinprep®) processing of urinary samples

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J Clin Pathol 2004;**57**:1208–1212. doi: 10.1136/jcp.2004.018648

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Accepted for publication 2 June 2004

Background/Aims: Liquid based cytology (LBC) was developed as a replacement for cytocentrifugation in the treatment of cell suspensions. Because accurate data comparing the quality and total cost of modern cytocentrifugation methods versus LBC in non-gynaecological samples are not available, this study was designed to investigate these issues.

Methods: The study comprised 224 urine samples treated with the Thermo Shandon Cytospin® 4 using reusable TPX® chambers, disposable Cytofunnels® for samples up to 0.5 ml, and disposable Megafunnels® for samples up to 6 ml. Each method was compared with the Cytyc Thinprep® processing of a paired sample. Quality was assessed by scoring cellularity, fixation, red blood cells, leucocytes, abnormalities of urothelial cells, and suitability for molecular studies. Wage costs, investment, and consumables allowed a ''total cost'' to be calculated on the basis of 200 specimens/month. Total cost and quality combined were used to calculate an index of total quality (ITQ).

Results: Cytocentrifugation with disposable chambers resulted in a global quality superior to that of Cytyc Thinprep LBC. Preparation and screening times were 2.25 and 1.33–2 times greater when using LBC compared with cytocentrifugation. The total cost each month reached 1960.23 $ to 2833.43 $ for cytocentrifugation methods and 5464.95 $ for Cytyc Thinprep LBC (92.8–178.8% increased cost). ITQ of cytocentrifugation with disposable chambers surpassed that of Cytyc Thinprep LBC (37.25/32.08 and 9.98, respectively).

Conclusion: Cytyc Thinprep LBC and cytocentrifugation are both appropriate methods for cytology based molecular studies, but cytocentrifugation remains the quality standard for current treatment of urinary samples because of its lower cost.

Urothelial carcinoma, which accounts for 90% of bladder cancer cases, is the fifth most common cancer in the European Union. More than 50 000 new cases are diagnosed annually in Europe and in North America.[1] About 70% of superficial (TNM stage pTa–1) bladder urothelial carcinomas will recur in the five years following transurethral resection (TUR), and 10–20% will progress to muscle invasion.[2] Therefore, patients treated for bladder cancer must be regularly followed up for the detection of recurrences.

> ''Despite being recognised as the biological standard for the follow up of bladder tumours, urinary cytology has a mean sensitivity of about 50% and is hampered by a large number of non-diagnostic samples''

Cystoscopy remains the standard for the diagnosis and surveillance of bladder tumours, allowing the lesions to be mapped and sampled. However, cystoscopy cannot explore the whole bladder urothelium, and cannot diagnose all carcinoma in situ cases or lesions of the upper urinary tract. Thus, it must be combined with urinary cytology, particularly in the search for tumour cells from high grade lesions, wherever their location in the urinary tract.

Despite being recognised as the biological standard for the follow up of bladder tumours, urinary cytology has a mean sensitivity of about 50% and is hampered by a large number of non-diagnostic samples.[3] Although urinary cytology detects about 80% of aggressive, high grade urothelial tumours, some results remain falsely negative, particularly in patients who have had TUR or bacillus Calmette-Guérin immunotherapy.

Liquid based cytology (LBC) using a filtration process and computer assisted thin layer deposition of cells has been developed as a replacement for cytocentrifugation and/or smearing, owing to its improved cell recovery capabilities and better cell preservation. In most published series, LBC allows a good interobserver reproducibility. In the urine, processing by the Cytyc Thinprep® 2000 (Cytyc Corp, Boxborough, Massachusetts, USA) results in increased cellularity and a pronounced reduction of debris, red blood cells (RBC), and crystals.[4–7]

However, optimisation of cell capture and fixation can be achieved by methods other than Cytyc Thinprep LBC, particularly while using meticulous modern cytocentrifugation methods in the study of hypocellular fluids.[7] In our experience based on 2500 specimens/year for 15 years, and provided specific technical requirements are followed, cytocentrifugation with Thermo Shandon Cytospin® (Thermo Electron Corp, Waltham, Massachusetts, USA) produces extremely good specimens, comparable to those obtained with LBC.

Accordingly, the aim of our study was: (1) to analyse objectively the quality of urine samples processed by modern cytocentrifugation methods compared with Thinprep LBC, (2) to verify whether any differences noted have an impact

Abbreviations: FISH, fluorescence in situ hybridisation; ITQ, index of total quality; LBC, liquid based cytology technique; RBC, red blood cells; TUR, transurethral resection

on diagnostic accuracy, and (3) to compare the cost efficiency performances of the methods studied.

MATERIALS AND METHODS

The study population was composed of 224 urine samples taken from 89 (39.7%) patients with symptoms suggesting bladder cancer (gross haematuria, micturition disorders, chronic urinary infection) and 135 (60.3%) patients being followed up after TUR for bladder urothelial carcinoma.

Urinary samples were taken after cystoscopy in 157 cases (70.1%), and after simple micturition in other cases. All samples were fixed with 50% ethanol (vol/vol) or with a 20% polyethyleneglycol 1500 (Merck, Darmstadt, Germany) solution in 50% ethanol.

Urine samples were sent to the laboratory and separated into two aliquots after homogenisation. One of the aliquots was processed by cytocentrifugation, and the other according to the Cytyc Thinprep LBC recommendations.

Cytocentrifugation methods

Cytocentrifugation was carried out in the Thermo Shandon Cytospin 4 in 224 cases. After centrifugation at 600 ×*g* for 10 minutes, hypocellular urine samples (< 50 µl cell pellet) were cytocentrifuged with sample chambers up to 0.5 ml, whereas large volume sample chambers were used for urine samples with a large pellet.

The Cytospin system uses centrifugation and fluid absorption principles and allows deposition of a thin layer of cells on round or rectangular areas. The deposition process requires sample chambers to be placed and locked into stainless steel Cytoclip® assembly devices. To test various types and qualities of sample chambers we used:

(1) Three years' old, round, reusable, autoclavable chambers designed for samples up to 0.5 ml (TPX® chambers with a cell deposition area of 6 mm diameter, allowing 28 mm^2 to be screened) in 44 cases.

(2) Round disposable chambers designed for samples up to 0.5 ml (single Cytofunnel® chambers with a cell deposition area of 6 mm diameter, allowing 28 mm^2 to be screened) in 90 cases.

(3) Large volume disposable chambers designed for samples up to 6 ml (Megafunnel® chambers with a cell deposition area of 21 × 14 mm, allowing 294 mm^2 to be screened) in 90 cases.

Two slides of 28 mm^2 screening area (for 1 ml of urine), and one slide of 294 mm^2 screening area (for 6 ml of urine) were prepared for each specimen studied.

Specially marked coated Cytoslides® provided by Thermo Shandon were used. Although not necessary, slides processed with TPX sample chambers had an additional treatment with a drop of coating medium (glycerin/albumin according to Mallory; Bayer Diagnostics, Puteaux, France) deposited on the sample area.

Smears were stained with a hypochromic Papanicolaou stain[8] before analysis.

Cytyc Thinprep 2000 processing

The urine was processed according to instructions for non-mucoid fluids provided by the manufacturer: samples were mixed with a Cytolyt® solution containing methanol and mucolytic and haemolytic agents, and were then centrifuged at 600 ×*g* for 10 minutes.

After discarding the supernatant, the cell pellet was mixed with a PreservCyt® solution and processed using the Cytyc Thinprep 2000 device. Using this automated system, thin layer cell preparations are produced by a controlled filtration process: after the TransCyt® filter has been plunged into the sample, it rotates at a high speed and facilitates cell and mucous dispersion. A vacuum is then applied to the filter, which collects cells on a 5 µm porosity membrane. During this process, cellularity is controlled by a software program until saturation. The TransCyt filter is inverted and a positive pressure allows cells to adhere to a slide.

Table 1 Cost efficiency analysis of cytocentrifugation methods versus Cytyc Thinprep (on the basis of 200 specimens/month)

	Cytocentrifugation methods*			
Criteria tested	**TPX**	**Cytofunnels**	**Megafunnels**	**Cytyc Thinprep**
Preparation time/10 specimens (**a**)	40 min	40 min	40 min	90 min
Preparation time/200 specimens	13 hr 20 min	13 hr 20 min	13 hr 20 min	30 hr
Monthly wage cost/cytotechnician† (**A**)	538.12 $	538.12 $	538.12 $	1210.78 $
Sample area	2×28 mm^2	2×28 mm^2	294 mm^2	314 mm^2
Mean screening time‡				
For 10 specimens (**b**)	10 min	10 min	15 min	20 min
For 200 specimens/month	3 hr 20 min	3 hr 20 min	5 hr	6 hr 40 min
Monthly wage cost/pathologist† (**B**)	193.81 $	193.81 $	290.72 $	387.63 $
Quality§, comfort, and reproducibility (**c**)	+	+++	+++	+++
Suitability for molecular studies (**d**)	NA	+	++	+++
Qualitative factor (**e**=c+d)	1	4	5	6
Investment cost (**C**)	10 430.40 $	10 430.40 $	10 430.40 $	29 482.00 $
Annual depreciation (**D**)	1043 $	1043 $	1043 $	2948 $
C−D/12	782.28 $	782.28 $	782.28 $	2211.16 $
Consumables/month (**E**)	337.07 $¶	524.44 $**	1113.36 $††	1318.45 $‡‡
Maintenance/year (**F**)	1307.42 $	1307.42 $	1307.42 $	4043.24 $
Total cost/month (**G**) A+B+(C−D/12)+E+F/12	1960.23 $	2147.60 $	2833.43 $	5464.95 $
Total cost/reportable case (G/200)	9.80 $	10.74 $	14.17 $	27.32 $
Index of total quality 100e/(G/100)(a+b/100)	10.20	37.25	32.08	9.98

*Including centrifugation for 10 minutes for up to 6/8 specimens (according to the centrifuge used) when necessary, and specific manipulations until the fixation step preceding staining; †salaries include charges and social security contributions (for calculation, see Materials and Methods section); ‡including dictation and encoding of the cytopathology report; §as determined by table 2 results; ¶TPX reusable, autoclavable chambers (63 €+VAT each, 12/year assuming regular renewal, that is 92.29 $)+filter cards (200/box, 37.10 € each+VAT, that is 54.34 $)+coated Cytoslides (100/box, 65 €+VAT each ×2, that is 190.44 $), amounting in total to 337.07 $/month inclusive of tax; **single disposable Cytofunnels with preattached filter cards (500/case, 570 €+VAT each ×0.4, that is 334.00 $)+coated Cytoslides, amounting in total to 524.44 $/month inclusive of tax; ††kits comprising Megafunnel disposable chambers with preattached filter cards and coated Cytoslides (25/box, 95 €+VAT each ×8), amounting in total to 1113.36 $/month inclusive of tax; ‡‡non-gynaecological kits (100 PreservCyt 20 ml flasks, 100 TransCyt filters, 100 Thinprep slides and 4l CytoLyt solution, 450 €+VAT each ×2), amounting in total to 1318.45 $/month inclusive of tax (with a 33% special discount).
NA, not attributed.

Table 2 Qualitative comparison of cytocentrifugation and Cytyc Thinprep methods (0–3 scale, paired series)

Criteria tested	N	Cytocentrifugation	Cytyc Thinprep LBC	p Value
TPX reusable chamber	44			
Cellularity		1.42 (0.65)	1.68 (0.58)	<0.001
Fixation		1.87 (0.70)	2.38 (0.52)	<0.00001
RBC		0.22 (0.39)	0.05 (0.15)	<0.001
Leucocytes		0.31 (0.38)	0.51 (0.49)	<0.02
Cell groups		0.36 (0.64)	0.40 (0.62)	NS
Atypias		0.69 (1.39)	0.77 (1.57)	NS
Positive (%)		6/44 (13.6%)	6/44 (13.6%)	NS
Disposable Cytofunnel	90			
Cellularity		1.79 (0.43)	1.56 (0.48)	<0.01
Fixation		2.12 (0.63)	2.54 (0.44)	<0.0001
RBC		0.45 (0.46)	0.06 (0.21)	<0.00001
Leucocytes		0.61 (0.63)	0.61 (0.90)	NS
Cell groups		0.25 (0.39)	0.22 (0.39)	NS
Atypias		0.85 (1.63)	0.72 (1.40)	NS
Positive (%)		3/31 (6.5%)	3/31 (6.5%)	NS
Disposable Megafunnel*	90			
Cellularity		1.85 (0.78)	1.69 (0.69)	NS
Fixation		2.17 (0.67)	2.74 (0.35)	<0.00001
RBC		0.50 (0.76)	0.04 (0.14)	<0.001
Leucocytes		0.83 (0.77)	0.45 (0.51)	<0.00001
Cell groups		0.16 (0.42)	0.20 (0.35)	NS
Atypias		0.82 (2.02)	0.77 (1.91)	NS
Positive (%)		3/31 (6.5%)	3/31 (6.5%)	NS

Values are mean (SD).
LBC, liquid based cytology; NS, not significant; RBC, red blood cells.

After insertion of another TransCyt filter and another slide, the whole procedure may be repeated until the entire sample is processed.

Using this procedure, the resulting cell deposition area is 20 mm in diameter, allowing 314 mm^2 to be screened. Cytyc Thinprep specific slides were used in all cases.

Analysis of morphological criteria

A single pathologist (EP) compared conventional and Cytyc Thinprep slides using an Olympus BHS microscope. Slides were placed side by side and were analysed under plan ×10, plan ×40, and oil planapo ×63 objectives. The global quality of slides was assessed by scoring cellularity, cell preservation, number of RBC, leucocytes, and degenerative changes of urothelial cells. The presence of cell groups and clusters of urothelial cells was also measured. Special attention was paid to altered cellular features potentially indicating malignant transformation—increased nuclear/cytoplasmic ratio, nuclear hyperchromatism, irregular nuclear shape, prominent nucleoli and mitoses—as described previously.[9]

All cellular features were coded from 0 to 3 according to their degree of abnormality.

The cytological results were categorised as positive or negative for urothelial tumour cells, whatever their grade. Normal, inflammatory, reactive, and degenerative conditions of the urothelial component were considered as negative, in addition to urothelial atypias of undetermined significance.

Numerical data were analysed using the paired series χ^2 test or Fisher's exact test, when appropriate, for mean comparisons. A probability of 0.05 was regarded as significant.

Cost efficiency evaluation

Several criteria including preparation time, characteristics of the sample, screening conditions, and costs were calculated, to provide objective measurements for comparison.

Measurements were done with a working hypothesis of 200 specimens each month. The costs of wages, investment, and consumables were calculated accordingly.

The mean preparation time for handling 10 consecutive specimens was calculated by three certified cytopathologists (KH, MCR, and JF). The mean screening time and characteristics of the sample were assessed by two experienced cytopathologists (EP and MC). The values obtained were multiplied by 20 and by the 2003 hourly rate, including charges and social security contributions of (1) a certified cytotechnician and (2) a full time pathologist given by the personnel department of the Hospices Civils de Lyon (teaching hospital of about 21 000 employees in the Rhône-Alpes region, France).

Cost calculation did not include standard laboratory material and consumables such as pipettes, glass containers, hoods, centrifuge, alcohols and solvents, stains, current automatons, or microscopes.

With regard to LBC and cytocentrifugation processors, we calculated the annual depreciation during a 10 year period. The cost of maintenance was based on contracts negotiated for 2003. Prices were indicated with 19.6% VAT. Values in $ were deduced from those calculated in euros using an exchange rate of 1.22487 $ for 1 €. Table 1 shows the formula used for calculating the total cost/month.

We attributed an ''index of total quality'' (ITQ) to the methods studied: we decided that quality and suitability for molecular studies (positive factors) had to be weighted against cost and time constraints (negative factors), thus allowing ITQ to increase when quality increases, and to decrease when cost or time constraints increase. Therefore, ITQ could be expressed by a specific formula, allowing direct comparisons between the methods studied (table 1).

RESULTS

Table 2 shows the mean and standard deviation data and the significance of comparisons calculated by means of the scoring system described earlier.

Differences noted between cytocentrifugation and Cytyc Thinprep LBC concern global quality (cellularity and fixation combined) on the one hand, and numbers of RBC and leucocytes on the other hand. Cytocentrifugation with disposable sample chambers allows a global quality superior to that of LBC to be obtained, whatever the type of sample chamber used.

In contrast, cytocentrifugation with three year old reusable sample chambers showed a significant decrease in both cellularity and fixation quality. We have not tested the value

of annual renewal of TPX chambers, but the cell yield is probably dependent on the chamber wall roughness, which is induced by successive washes.

Contamination by RBC is significantly decreased after Cytyc Thinprep processing of samples in all circumstances. The same can be said for leucocytes and microorganisms, so that the background is clearer after LBC treatment.

The identification of different cell groups and atypias was similar between all the cytocentrifugation methods studied and Cytyc Thinprep LBC, indicating that despite differences in quality, the technique has no impact on the diagnostic accuracy as evaluated by the rate of abnormalities.

Table 1 details the cost comparisons. Investment for cytocentrifugation is 7120 € plus VAT, that is 10 430.40 $ inclusive of tax (2004 basis for a Thermo Shandon Cytospin 4 with standard equipment). The extra equipment needed (sample chambers+Cytoslides) amounts to a total of 230.10 €, 358 €, or 908.96 €+VAT/month, that is 337.07 $, 524.45 $, or 1113.36 $ inclusive of tax/month, according to the type of sample chamber used.

Cytyc Thinprep LBC needs a 20 125 €+VAT investment (that is 29 482.00 $ inclusive of tax), together with a maintenance contract of 2300 € annually+460 € for parts and labour, amounting to a total of 4043.24 $ inclusive of tax. The extra equipment needed is packed in non-gynaecological kits and accounts for 900 € plus VAT/month, that is 1318.45 $/month inclusive of tax (with a 33% special discount).

The working time of a cytotechnician processing 200 specimens/month is 13 hours and 20 minutes for cytocentrifugation and 30 hours for LBC (×2.25). The mean cost of wages for a full time technician working in a French teaching hospital is 50 750 € for 1540 hours annually (32.95 €/hour, including charges and social security contributions). Taking into account mean preparation times, the wage cost would be 439.33 € (538.12 $) or 988.50 € (1210.78 $), according to the method used.

The screening time of a pathologist reading 200 specimens/month varies between three hours and 20 minutes or five hours for cytocentrifugation methods and six hours and 40 minutes for LBC (×2.0 and ×1.33, respectively). The mean cost of wages for a full time practitioner working in a French teaching hospital is 101 780 € for 2144 hours annually (47.47 €/hour, including charges and social security contributions). Accordingly, the wage cost would be 158.23 € (193.81 $) to 316.46 € (387.63 $), according to the screening time calculated.

According to specific wage costs, investment, and consumables, the total cost each month would be 1960.23 $ to 2833.43 $ for cytocentrifugation methods and 5464.95 $ for LBC (92.8%, 154.5%, and 178.8% greater than the cost for cytocentrifugation using the Megafunnel, Cytofunnel, and TPX sample chambers, respectively).

According to the definition of ITQ given earlier, we attributed a 10.20, 37.25, and 32.08 index to cytocentrifugation with the TPX, Cytofunnel, and Megafunnel sample chambers, respectively, whereas Cytyc Thinprep LBC only reaches a 9.98 index because of its higher cost and longer testing times.

DISCUSSION

Voided urinary cytology has been used since 1945 as the only available non-invasive test for monitoring bladder cancer, but it is limited by observer subjectivity, a 15–30% sensitivity in detecting low grade (G1–2) bladder tumours, and sometimes false negativity in high grade urothelial tumours.[3]

As far back as the late 1970s, authors have attempted to compare cytocentrifugation with other methods of cell concentration, such as filtration.[10 11] In those preliminary studies, Millipore® filtration was found to give better cell recovery and better morphological details than cytocentrifugation. However, the cell concentration method used (reusable sample chambers) was probably suboptimal. We have previously shown that significant cell loss can be attributed to the roughness of reusable sample chamber walls secondary to repeated cleaning.[12]

Only in the 1990s did comparisons between the Cytyc Thinprep LBC processor and other methods of concentrating cell suspensions become possible, with some contradictory results. Many of the studies were published as abstracts of the 40th and 41st annual scientific meetings of the International Academy of Cytology, but they were not transformed into full length articles.[6 13 14]

Apart from one study, which showed comparable diagnostic quality but processing time and cost several times greater for LBC than for polycarbonate membrane filtration,[7] most series recognise advantages in using LBC, particularly because of the reduction in RBC and leucocytes. Only one study found that acute inflammation was increased after Cytyc Thinprep treatment of urinary samples.[13]

In a more recent study comparing cytocentrifugation to Cytyc Thinprep LBC, Cytospin preparations were found to be relatively superior to LBC in terms of cytomorphological details and the preservation of architectural patterns.[15] However, the advantage of LBC with regard to a cleaner background was noted.

Cytocentrifugation and LBC are not the only available methods for improving diagnostic accuracy in urine cytopathology: potentially interesting results were shown by Albright and Frost.[16] Using a simple density gradient to separate atypical cells from normal urothelial cells after fixation with the Saccomanno method (equivalent to our polyethyleneglycol 1500 alcoholic solution), these authors were able to enrich up to 20-fold the atypical and cancer cell fraction. Moreover, most of the leucocytes were absent from the corresponding density gradient level. To our knowledge, however, these results have not been verified since.

In fine needle aspiration specimens, conventional preparations with direct smears and Cytyc Thinprep slides were compared with regard to cellularity, background blood and debris, cell architecture, and nuclear and cytoplasmic details in a series of 71 cases.[17] The results showed that LBC, despite requiring more experience for interpretation, was superior to smears owing to a clear background, monolayer cell presentation, and cell preservation.

LBC methods other than Cytyc Thinprep have been compared with cytocentrifugation in non-gynaecological samples: in a study comparing cytocentrifugation with both Cytyc Thinprep and AutoCyte® PREP (TriPath Imaging, Burlington, North Carolina, USA) systems,[7] the diagnostic performance of the three methods was identical diagnostically. One slide obtained with the LBC techniques was comparable to four Cytospin slides.

> ''In our opinion, one must consider not only the diagnostic performance, but also the ultimate goal of technical improvements such as those provided by liquid based cytology''

A more recent study assessed the quality and cost of AutoCyte PREP compared with cytocentrifugation of urine specimens in a general laboratory setting.[18] It was shown that the Cytospin method, despite longer preparation time, had a shorter screening time, a higher number of diagnostic cells, and better fixation and staining qualities than the AutoCyte PREP system. In addition, the Cytospin method was seven times less expensive than the AutoCyte PREP method.

Take home messages

- We compared the cost, quality, and suitability for molecular analyses of Cytyc Thinprep liquid based cytology (LBC) and cytocentrifugation for the processing of urinary samples
- Although both methods were appropriate for cytology based molecular studies, cytocentrifugation using disposable sample chambers remains the quality standard for current treatment of urinary samples because of its lower cost and reduced time constraints
- LBC methods may be superior for use in university hospitals, cancer centres, and clinicobiological research teams, where molecular studies and chromosomal analysis form an important part of the medical assessment

Those results, at first sight, seem to be unfavourable to LBC techniques. A recent review from the Papanicolaou Society of Cytopathology for urinary cytology procedures and reporting[19] does not give clear technical recommendations, except that ''traditional membrane filter techniques are rarely used and are not currently recommended'', and concerning LBC, that ''the manufacturer's recommendations should be followed'', such advice being of limited practical usefulness.

In our opinion, one must consider not only the diagnostic performance, but also the ultimate goal of technical improvements such as those provided by LBC. LBC aims primarily to provide well preserved material from the residual vial for additional techniques such as immunocytochemistry, fluorescence in situ hybridisation (FISH), and other types of molecular analyses. Several methods suitable for FISH studies are commercially available, including the Cytyc Thinprep and AutoCyte PREP processors,[20] and modern cytocentrifugation techniques.

It has been shown that Cytyc Thinprep processed samples allowed efficient recovery of the DNA, RNA, and proteins related to the p53 tumour suppressor gene.[20] FISH techniques can be applied with success and reproducibility on Cytyc Thinprep prepared urinary samples (unpublished data provided by Vysis Inc, Downers Grove, Illinois, USA).[21] This method allows unprocessed samples to be stored in the PreservCyt solution, which preserves the DNA, RNA, and proteins so that they remain suitable for molecular analyses even after several months of storage at +4℃ or at −20℃.[21]

Our results enable us to make a few practical points. Cytocentrifugation with reusable chambers should be avoided if annual renewal cannot be guaranteed, because of the considerable cell loss induced by repeated cleaning. Although we have not tested the quality of new TPX sample chambers, it is probably similar to that of disposable chambers.

Cytocentrifugation using disposable chambers (Cytofunnel or Megafunnel chambers) gives excellent results, equalling or surpassing LBC if ones considers both cellularity, fixation, and comfort for screening.

A comparison of the monthly cost of the two most efficient methods (cytocentrifugation with disposable Megafunnels and Cytyc Thinprep LBC) shows that the cost of LBC is 92.8% higher and the time constraints are 2.25 times greater. Accordingly, despite its value for additional molecular techniques, Cytyc Thinprep LBC shows the lowest ITQ of the various methods studied.

With regard to technical constraints and cost, differences noted in our study necessarily influence the allocation of tasks in the pathology laboratory and have strong implications for decision making. Cytyc Thinprep and perhaps other LBC methods, despite their cost, could be better used in a public setting (university hospitals, cancer centres, clinicobiological research teams), where molecular studies and chromosomal analysis form an important part of the medical assessment.

We conclude that Cytyc Thinprep LBC and modern cytocentrifugation techniques are appropriate methods for cytology based molecular studies. From an economical point of view, and taking into account the value of a meticulous technique, cytocentrifugation with disposable sample chambers remains the quality standard for current treatment of urinary samples.

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