Journal of Chromatography, 109 (1975) 149–162

CHROM. 8213

COMPARISON OF COSTS* FOR TESTING A WIDE VARIETY OF DRUGS OF ABUSE PER URINE SPECIMEN IN A DRUG ABUSE URINE SCREENING PROGRAM AND FREQUENT URINE COLLECTIONS

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(Received January 28th, 1975)

SUMMARY

Existing urine testing techniques in a drug abuse urine screening program with their capacity to analyze urine specimens per day are discussed. The start-up cost using each technique and cost per specimen are presented. A single step extraction technique using ion-exchange paper to absorb drugs prior to thin-layer chromatography (TLC) as reported by these laboratories will cost $0.58 per specimen, detecting opiates and performing at least four tests per specimen, and $0.82 per specimen, for testing the entire array of drugs of abuse (at least 9–14 tests per specimen). Sensitivity reported using TLC technique for the morphine base is 0.15 μg/ml (minimum volume of urine needed 20 ml), 0.10 μg/ml if the volume of urine available is 30–35 ml, and 0.07 μg/ml if the volume of urine available is 43–50 ml.

Urine screening for abused drugs has become a necessary adjunct in prevention and treatment programs, since it provides a clinician an objective measure of drug abuse among his clients. Urine analysis is also desired for pre-employment screening of job applicants, evaluation of impaired workers, detection of drug users among criminals and for the detection of stimulant drugs in athletes. A forensic toxicologist dealing with medicolegal cases requires qualitative and quantitative data, while the primary concern of drug abuse prevention and treatment programs is to determine the progress of a particular treatment modality, hence only qualitative information is required. Furthermore, large-scale drug abuse prevention and chemotherapeutic maintenance programs require simple, rapid, sensitive, reliable, versatile and low-cost urine screening procedures.

The purpose of this communication is to report the cost of analysis per urine specimen for detecting the entire array of drugs of abuse and also to discuss in some detail the comparison of speed and analysis using currently existing detection tech-

* All prices quoted are in United States dollars.

niques. During the past three years potentially useful immunoassay techniques such as radioimmunoassay (RIA[1,2]), free radical assay technique (FRAT[3,4]), hemagglutination, inhibition test (HI[5,6]), latex flocculation test (LFT[7]), and enzyme multiplied immunoassay technique (EMIT[3,8]), applicable to drug abuse screening programs, have been developed. These techniques are prohibitive in cost and usually selective in what drugs they are able to test. Although RIA, FRAT, and HI techniques have a sensitivity of nanograms level for the detection of morphine and structurally related narcotics, the chances of cross-reactivity with other drugs enhance at this level. Dextromethorphan and Demerol (Mepridine)[1,2,9] are known to cross-react in most morphine tests, thus giving a false positive morphine. Codeine, which is one of the common components of cough medicine and whose presence can be misinterpreted as heroin abuse, cannot be differentiated from morphine by all the existing immunoassay techniques. In addition, people who have ingested certain foods with high content of poppy seeds[1,2,9] often excrete urine that may give a false positive result. Therefore, all positive results obtained by immunoassay techniques are ambiguous and must be confirmed by a non-immunological procedure of comparable detection limits, while all negative results may be considered reliable.

Recently, we reported a single-step extraction and thin-layer chromatographic (TLC) identification technique for a wide variety of drugs of abuse[10,11], using ion-exchange paper. Recent shift in emphasis from heroin abuse to poly-drug use has further necessitated the testing of entire drugs of abuse in one step. In many treatment programs serious attempt is made to rehabilitate a wide variety of drug abusers, opiates as well as non-opiate users. A significant percentage of clients take prescribed tranquilizers, antibiotics, and other types of needed drugs, it is therefore necessary that a mass screening technique should be capable of detecting a wide variety of substances and of differentiating illicit drugs and their adulterants from legitimate and prescribed drugs and their metabolities.

At present, TLC is the technique which meets the above criteria and can immediately alert the operator of the number of drugs and/or their metabolites present in a urine specimen. Gas–liquid chromatography (GLC), the only other technique that can permit simultaneous screening of a mixture of drugs, is time consuming and more expensive than TLC, since it has the inherent disadvantage of running one specimen at a time.

Due to the increased usage of drugs, more and more out-patient and in-patient treatment programs for drug-dependent individuals are being established throughout the country. To ensure that none of the heroin users are kept on a waiting list due to lack of funds (for urine testing), significant funds are being provided either to get urine analysis from outside testing facilities or to establish in-house testing facilities. However, we have noticed that in some in-house testing facilities, costly detection techniques, such as RIA, and other immunoassay techniques are being used to detect the drugs of abuse. Many programs resort to only one collection of urine per week to save the expenses which would be incurred when two or three collections of urines were made. Under the existing U.S. Federal Regulations, the urine of every client attending drug abuse prevention and chemotherapeutic maintenance programs needs to be tested randomly once a week for morphine and once a month for opiates, amphetamines, barbiturates, and other drugs as needed. However, the authors feel that frequent collection of urine has a strong deterrent effect on the use of drugs[12].

Therefore, one collection of urine per week on random basis as proposed under the Federal Regulations for every client regardless of the length of stay with a program and without following the progress of the treatment is inadequate and can encourage the clients for use of drugs, thus vitiating the very purpose of urine surveillance in chemotherapeutic maintenance and drug abuse prevention clinics. The authors feel that frequent urine collection and data generated from urine analysis are highly imperative to assess the effectiveness and efficacy of management techniques. Hence, we suggest that a client must drop at least three urines a week for the first six months of entering a treatment program, subsequently this condition may be made less rigid to only two drops a week, depending upon the progress of each individual client in a particular treatment modality. If a client's urine report is clean for a period of six months, only then one collection of urine per week on random basis will be sufficient as a check for covert drug use. To decrease the expenses which would be incurred on frequent urine analysis, the authors recommend that only one test may be performed per week by pooling various urine specimens of different visits of the same client. The pooling of different urines can be accomplished by absorbing drugs on a cation-exchange resin loaded paper at the urine collection station at the time of each visit of the client and then pooling the ion papers representing different urine specimens. Pooling of ion papers representing different urine specimens enhances the possibility of increasing the sensitivity since the human body continues the excretion of drugs and/or their metabolites in minute concentrations for more than 48 h. Furthermore, it will enable the clients' different urine specimens to be tested without entailing any extra cost (see Fig. 1).

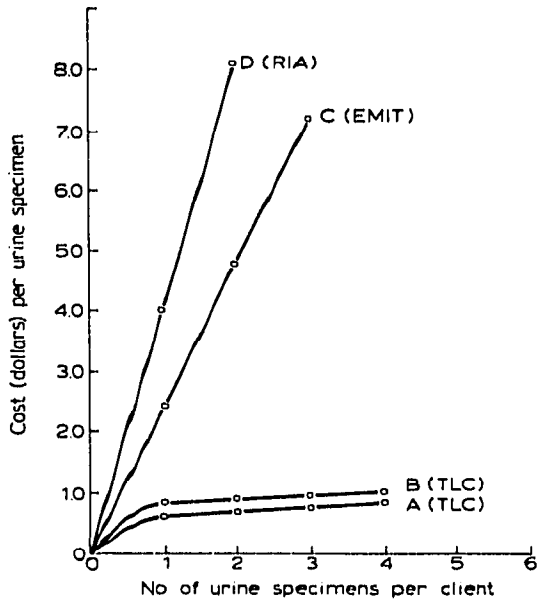

Fig. 1. Effect of pooling ion-exchange papers representing different urines of a client using TLC and its cost in comparison to EMIT and RIA. A, Pooling of ion-papers representing different urine specimens and performing at least 4–5 tests per specimen for opiates (TLC); B, same as A but testing the entire array of drugs of abuse, *i.e.*, at least 9–14 tests per specimen (TLC); C, EMIT, each specimen has to be tested individually and the cost represents 4 tests per specimen; D, RIA, cost represents 4 tests per specimen.

TABLE I

CURRENT TECHNIQUES AND DELIVERY OF URINE SPECIMENS PER DAY (7.5 h)

TLC	*GLC*	*Spectrophotofluorometric tests (SPF)*	
		*ATS** (Farrand automated turret spectrofluorometer)*	*Technicon automated SPF system****
120 specimens if only opiates are tested, performing at least four to five tests per specimen, *i.e.*, morphine, codeine, methadone, quinine, etc.[11] 80 specimens if the entire array of drugs of abuse[11], *i.e.* morphine, codeine, methadone, quinine, amphetamine, methamphetamine, phenmetrazine (Preludin), methylphenidate (Ritalin), secobarbital or pentobarbital, or amobarbital or hexobarbital, phenobarbital, glutethimide (Doriden), diphenylhydantoin (Dilantin), propoxyphene (Darvon), meperidine (Demerol) and unchanged cocaine are tested concurrently, thereby performing at least nine to fourteen tests per specimen. In fact, many more drugs of abuse can be tested[11] per specimen without increasing the cost.	25 Specimens per day* for screening of opiates and a few amphetamines. One sample takes about 20–30 min for complete elution.	400 specimens performing one test per specimen.	300 specimens performing one test per specimen.

* Some laboratories may be able to process 45 samples or more per day by using two detectors and by varying the various parameters, such as diameter, length, temperature of column, and carrier gas flow, etc.

** This instrument needs extraction of morphine and quinine prior to its conversion to a fluorophore. The use of ATS is limited to test morphine, quinine and meperidine only.

*** This instrument has been withdrawn from the market but it can be purchased. The procedure is limited to test morphine and methadone only.

Immunoassay techniques[§]				
EMIT (automated)	*FRAT*	*RIA*	*HI*	*LFT*
450–500 specimens[§§] performing one test per specimen.	400 specimens[§§§] performing one test per specimen.	625 specimens[†] performing one test per specimen. Bivalent reagents capable of testing morphine and barbiturates simultaneously are available but all positives will have to be redone for morphine and barbiturate individually by using monovalent morphine and barbiturate reagents.	300–400 specimens performing one test per specimen. Reagents for testing other drugs are not commercially available	300–400 specimens performing one test per specimen. This test is not commercially available as yet.

[§] The delivery of specimens tested per day using immunoassay techniques varies as a function of the number of tests performed per specimen. Thus an assay capable of performing 450 tests per day will do 90 specimens every day if five tests are performed per specimen. Practical considerations such as repeating certain samples and the need to include a standard of the various drug abuse calibrators will further reduce the above output.

[§§] EMIT automated Gilford can perform 500 tests, EMIT automated Abbot (ABA 100) can perform 1050 tests and Manual Emit Gilford can perform 300 tests per day (8 h). These figures are claimed by Syva Corporation, while our experience with Manual Emit Gilford proved that a maximum number of 120 tests per day could be performed. Furthermore, practical considerations such as repeating certain samples and the need to run various calibrators reduces the output further. Reagents to test opiates, methadone, amphetamine, barbiturate, and cocaine metabolite are commercially available.

[§§§] Practical considerations such as repeating certain samples and the need to include standards will reduce the output. Reagents to test opiates, methadone, amphetamine, barbiturate, and cocaine metabolite are commercially available.

[†] Although Roche Diagnostics claims the above figure of 625 tests per day, we feel that the feasible number of tests that can be performed per day is 350–400. Practical considerations such as repeating certain samples and the need to include standards will reduce the output.

TABLE II

COST COMPARISON USING VARIOUS TECHNIQUES

	TLC		*GLC*		*SPF techniques*			
					ATS		*Technicon automated SPF system*	
Labor cost per day (7.5 h) approx. $ 4.56 per hour.		$ 34.20		$ 34.20		$ 34.20		$ 34.20
Reagents and pertinent supplies	(i) Chemicals and TLC supplies approx. $ 0.20 per specimen	$ 24.00	Chemicals and other materials approx. $ 0.12 per specimen	$ 2.64	Reagents and supplies approx. $ 1.0 per specimen	$ 400.00	Reagents and supplies approx. $ 0.10–$ 0.18 per specimen	$ 30.00
	(ii) SA-2 cation-exchange resin loaded paper approx. $ 0.0675 per* 6 × 6 cm sheet	$ 8.10	Total	$ 36.84	Total	$ 434.20	Total	$ 64.20
	(iii) Minigrip bags (plastic bags) to transport ion-exchange paper approx. $ 0.02 per bag**	$ 2.40						
	Total	$ 68.70						
	per 120 specimens or $ 0.58 for performing at least four to five tests per specimen for opiates only, and $ 0.82 per specimen for testing the entire array of commonly abused drugs as listed in Table I for performing at least nine to fourteen tests per specimen (eighty specimens per day); chemicals and thin-layer supplies calculated at the rate of $ 0.30 per specimen.		per 25 specimens or $ 1.48 per specimen; $ 0.88 per specimen if 45 specimens are analyzed per day for performing at least five to seven tests per specimen.		per 400 specimens or $ 1.09 for performing one test per specimen.		per 300 specimens or $ 0.22 to $ 0.29 for performing one test per specimen.	

* The price per box of 100 sheets each of 6 × 6 cm goes considerably down depending upon the quantity purchased.

Price per box	*Quantity of boxes to be purchased*
$ 6.75	1–99
$ 5.85	100–499
$ 5.30	500–999
$ 5.00	1000–1499
$ 4.75	1500–1999
$ 4.45	2000–over

** The price per carton of 1000 Minigrip bags each of 3 × 4 in. goes considerably down depending upon the quantity purchased.

Price per carton	*Quantity of cartons to be purchased*
$ 25.80	1
$ 19.55	5
$ 13.50	10
$ 8.60	25
$ 7.85	50
$ 7.60	100

*Immunoassay techniques****

EMIT		*FRAT*		*RIA*		*HI*		*LFT*
	$ 34.20		$ 34.20		$ 34.20		$ 34.20	$ 34.20
Reagents cost approx. $ 0.50 per test	$ 225.00	Reagent cost§§ approx. $ 1.36 per test	$ 544.00	Reagent cost approx. $ 1.10 per assay§§§	$ 625.00	Reagent cost approx. $ 0.34 per test†††	$ 136.00	Latex flocculation test similar to pregnancy test is placed on the market by Roche Diagnostics and its price per test is still to be fixed when it becomes commercially available. Authors are validating the results obtained by LFT with TLC and EMIT.
Ancillary supplies including buffer, bacteria, drug abuse calibrators, disposable beakers approx. $ 0.02 per test	$ 9.00	Ancillary supplies approx. $ 0.12 per test	$ 48.00	Ancillary supplies approx. $ 0.20 per assay†	$ 125.00	Ancillary supplies and shipping cost approx. $ 0.08 per test	$ 32.00	
Total	$ 268.20	Total	$ 626.20	Total	$ 784.20	Total	$ 202.20	
per 450 specimens or $ 0.60 for performing one test per specimen§. A urine specimen will cost $ 1.20 to perform two tests per specimen and $ 3.0 to perform five tests per specimen. Reagents cost per 100 assay is $ 0.74 per test but if single reagent worth 1000 assays is purchased at a time, it will cost $ 0.50 per test.		per 400 specimens or $ 1.57 for performing one test per specimen. If a single reagent worth 1000 assays is purchased at a time, the price per assay is $ 0.50 and then the cost per specimen for performing one test per specimen comes to be about $ 0.71, and $ 2.84 for performing four tests per specimen.		per 625 specimens†† or $ 1.26 for performing one test per specimen. A urine specimen will cost $ 4.64 if four tests are performed per specimen. A bivalent reagent capable of testing morphine and barbiturates simultaneously will cost $ 1.50 per test but all positives will have to be redone for morphine and barbiturates by using monovalent morphine and barbiturate reagents.		per 400 specimens or $ 0.51 for performing one test per specimen.	

*** Positive results obtained by immunoassay techniques have to be validated by a non-immunological back-up procedure, thereby resulting in substantial increase in the cost per test.

§ Since this method is based on lyso-enzyme, which is chemically bound to the drug in question, urine specimens having naive or endogeneous lyso-enzyme activity will give false positives for all drugs detected using this system. Therefore, all low-positive EMIT readings must be rechecked by running a blank of the same urine specimen without using antibody and enzyme reagents. This recheck will further increase the cost of analysis per test. Also refer to footnote *** given above on the validation of all positive results.

§§ The regular price is $ 1.50 per assay but the purchaser is entitled to a special rate of $ 1.36 per assay if federal money is used to perform the test[9]. This price needs no commitment on the part of the purchaser.

§§§ $ 1.0 per assay if reagents worth 2300 tests are committed to purchase[9]. The cost of reagent per assay goes considerably down depending upon the quantity purchased.

Cost per assay	*Quantity to be purchased*
$ 1.0	100 assays (1 kit)
$ 0.75	2,400 assays (24 kits)
$ 0.60	9,600 assays (96 kits)
$ 0.52	48,000 assays (480 kits)
$ 0.46	240,000 assays (2400 kits)
$ 0.43	500,000 assays (5000 kits)
$ 0.41	1 million assays (10,000 kits)

To perform 48,000 assays a year (930 test per week) will cost about $ 25,000.

† The cost varies from $ 0.17 to $ 0.32 per test

†† This figure of 625 tests per day is according to Roche Diagnostics but we feel that the feasible number of tests that can be performed per day is 350–400.

††† The cost varies according to the number of tests purchased per month and the particular way the test is used. If concentrated serum is used, the price of reagent per test lowers down to $ 0.27. There is a 5% reduction if the reagents purchased per month exceed 3000 and a 10% reduction if the reagents purchased per month exceed 5000[9]. Methadone reagent is likely to be available in the near future.

TABLE III

START-UP COSTS OF VARIOUS TECHNIQUES

TLC	*GLC*	*SPF techniques*	
		ATS	*Technicon automated SPF system*
The start-up cost of a toxicology laboratory using the TLC technique was reported recently[13,14]; equipment about $2200; expendables and glassware sufficient for handling 500 specimens per week about $1800; chemicals and reagents approx. $400.	A gas chromatograph with dual FID costs $4000–$8000. Columns, column packings and miscellaneous supplies cost $500.	Farrand ATS costs about $6000, but can be leased or rented (Farrand Optical Co., Valhalla, N.Y., U.S.A.).	Technicon Auto Analyzer costs about $25 000. The instrument has been withdrawn from the market but the investigators interested in automation can still purchase this instrument; it can also be leased or rented (Technicon Instruments Corp., Tarrytown, N.Y., U.S.A.).

Immunoassay techniques

EMIT	*FRAT*	*RIA*	*HI*	*LFT*
Emit manual Gilford costs about $7100; ancillary reagents, calibrators, and hardware needed with the spectrophotometer cost about $200. EMIT automated Gilford costs about $10 900 and EMIT automated Abbot (ABA 100) costs about $26 000. Syva Corporation, Palo Alto, Calif., U.S.A. will supply EMIT manual Gilford free if the user commits to buy reagents worth 1000 tests every week on a yearly basis; it will supply the automated Gilford free if the user commits to buy reagents worth 2000 tests every week on yearly basis; and it will supply the automated Abbot (ABA 100) free if the purchaser commits to buy reagents worth 7000 tests every week on yearly basis.	ESR spectrometer by Syva Corporation costs about $26 000.	A gamma counter is needed to use the ^{125}I RIA system and a liquid scintillation counter is needed to use the ^{3}H RIA system. A gamma counter with teletype writer costs about $9500; a liquid scintillation counter costs about the same price. A centrifuge machine will be needed, which costs about $500 or less. Roche Diagnostics can ammortize the gamma counter, micro-medic automatic pipetting station and centrifuge machine with reagents cost.	This technique does not need expensive and complicated equipment; it needs a simple centrifuge, titer trays and a few Pasteur pipets.	This technique needs heating blocks (specially designed to perform this test); 400 µl and 100 µl automatic pipets, and disposable specially designed test tubes. The start-up cost is less than $500.

TABLE IV

SENSITIVITY OF VARIOUS TECHNIQUES

TLC	*GLC*	*SPF techniques*	
		Farrand ATS	*Technicon automated system*
The sensitivity of TLC identification techniques using ion-exchange paper to absorb the drugs from urine as reported recently by these laboratories[11] for a wide variety of drugs of abuse was: morphine base, 0.15 μg/ml (0.20 μg/ml morphine HCl, H_2O); codeine phosphate, 0.5 μg/ml; methadone HCl, 1.0 μg/ml; amphetamine sulfate, 1.0 μg/ml; methamphetamine HCl, 0.5 μg/ml; methylphenidate (Ritalin), 1.0 μg/ml; phenmetrazine HCl (Preludin), 0.5 μg/ml; phenobarbital, 0.5 μg/ml; and secobarbital, 0.36 μg/ml of urine. All these sensitivities were achieved using 20 ml of urine. Using 30–35 ml of urine, morphine (base) can be detected at a level of 0.10 μg/ml of urine and using 43–50 ml of urine, morphine (base) can be detected at a level of 0.07 μg/ml of urine. Laboratories other than proficient laboratories can also achieve the above sensitivities if the steps reported are followed. Kullberg and Gorodetzky[15] have recently reported a sensitivity of 0.07 μg/ml of urine for morphine base using a XAD-2 resin column.	Morphine 0.1–0.5 μg/ml; barbiturates and amphetamines, 1.0–2.0 μg/ml of urine.	Mulé and Hushin[16] have reported a sensitivity of 0.22 μg/ml of urine for morphine base.	Technicon claims a sensitivity of 0.20 μg/ml of urine for morphine base; however, these data need validation.

Immunoassay techniques

EMIT	*FRAT*	*RIA*	*HI*	*LFT*
Morphine, 0.5 μg/ml; methadone, 0.5 μg/ml; amphetamine, 1–2 μg/ml; barbiturate, 1–2 μg/ml; and benzoyl ecgonine, 1.0 μg/ml (Syva Corporation recommends a cut-off limit of 0.3 μg/ml for morphine and methadone; 1.0 μg/ml for amphetamine and barbiturate for urine specimens submitted for Proficiency Testing by Center for Disease Control (CDC) Atlanta, Ga., U.S.A.).	Morphine, 0.1–0.5 μg/ml (incidence of false positives for morphine at a higher sensitivity level of 0.1 μg/ml is possible), amphetamine, barbiturate, and benzoyl ecgonine, 1.0 μg/ml; methadone, 0.5 μg/ml, as claimed by Syva Corporation.	25–100 ng/ml of urine for morphine (the incidence of cross-reactivity with other drugs at 25–40 ng level could be high).	25–50 ng/ml of urine for morphine (the incidence of cross-reactivity with other drugs at 25–50 ng level could be high but by selecting a decreased sensitivity of 100–200 ng/ml this incidence of false positives can be minimized).	100–200 ng/ml of urine (by purchasing concentrated antibody, user can select any sensitivity between 100–300 ng/ml of urine).

TABLE V
SUMMARY

	Delivery of urine specimens per day (7.5 h)	*Cost per specimen*	*No. of tests performed per specimen*	*Start-up cost*	*Sensitivity*
TLC	120 80	$0.58 $0.82	4–5 9–14 or more	Equipment, expendables and chemicals, $4,400 (refs. 13, 14)	Morphine base, 150 ng; methadone HCl, 1.0 μg; amphetamine sulfate, 1.0 μg; methamphetamine HCl, 0.5 μg; phenobarbital, 0.5 μg/ml of urine (urine needed 20 ml); morphine base, 70 ng/ml of urine (urine needed 43–50 ml); morphine base 100 ng/ml of urine (urine needed 30–35 ml). Refer to Table IV.
GLC	25–45 (see footnote *, Table I)	$1.48–$0.88	5–7	$4,500–$8,500	Morphine base, 100–500 ng/ml; barbiturates and amphetamines, 1.0–2.0 μg/ml of urine.
ATS (Farrand automated turret spectrofluorometer)	400	$1.09	1	$6,000	Morphine base, 220 ng/ml of urine[16]
Technicon automated SPF system	300	$0.22–$0.29	1	$25,000	Morphine base, 200 ng/ml of urine
EMIT	450–500 (see footnote §§, Table I)	$0.60 (see footnotes *** and §, Table II)	1	Manual $7,100; Gilford automated, $10,900; Abbott automated (ABA-100), $26,000 plus $200 ancillary supplies and hardware	Morphine, 500 ng; methadone, 0.5 μg; amphetamine, 1–2 μg; barbiturates, 1–2 μg; and benzoyl ecgonine, 1.0 μg/ml of urine (Syva recommends a cut-off of 300 ng/ml of urine for morphine and methadone for Proficiency Testing of Urine Specimens).
FRAT	400 (see footnote §§§, Table I)	$0.71–$1.57 (see Table II under FRAT and also footnotes *** and §§, Table II)	1	$26,000	Morphine, 100–500 ng; amphetamine, barbiturate, and benzoyl ecgonine, 1.0 μg; and methadone, 0.5 μg/ml of urine
RIA	625 (see footnote †, Table I)	$1.26 $1.50 (see Table II under RIA and also footnote ***, Table II)	1 2 (see Table II under RIA)	$10,000	Morphine, 25–100 ng/ml of urine (incidence of cross-reactivity with other drugs at 25–40 ng level could be high).
HI	300–400	$0.51 (see footnote ***, Table II)	1	$500.0 approx.	Morphine, 25–50 ng/ml of urine (incidence of cross-reactivity with other drugs at this level could be high, but this can be minimized by selecting a decreased sensitivity of 100–200 ng/ml of urine)
LFT	300–400	Not known as yet	1	$500.0 approx.	100–200 ng/ml of urine

Pooling of different urines is not feasible using the EMIT since it involves the risk of diluting the sensitivity of the test by mixing a positive urine with one or more negative urines. Similarly, urine monitoring using Amberlite XAD-2 (non-ionic) polymeric resin columns at the clinics is not possible as this would need the services of a trained operator. Furthermore, it will be virtually impossible to pool the various urine specimens for different visits of one client using the same resin column since it has to be stored in a refrigerator after the urine has been passed through to avoid the formation of channels due to drying of the resin. In addition, the shipping of the above wet columns to the laboratories will create technical problems.

Data regarding existing techniques, delivery of urine specimens per day, cost of monitoring various drugs per specimen, start-up cost of each technique and their sensitivities are presented in Tables I–V. Table I shows the delivery of urine specimens using each technique. Thus far, TLC eminently appears to be the only technique which is simple, inexpensive, reliable and versatile. A technician using the single-step extraction technique as reported by these laboratories[10,11] can detect a minimum of fourteen drugs at a time in a single urine specimen costing approximately $0.82, while testing for opiates performing four to five tests per specimen will cost $0.58. These figures include labor, reagents, chemicals and TLC supplies calculated on the basis of 600 urine specimens per technician per week for opiates and 400 urine specimens for detecting the entire array of drugs of abuse. On the other hand, immunoassay techniques are exorbitant in cost: A single test per urine specimen using EMIT will cost $0.60 and will cost more than a $1.0 using FRAT or RIA. The total

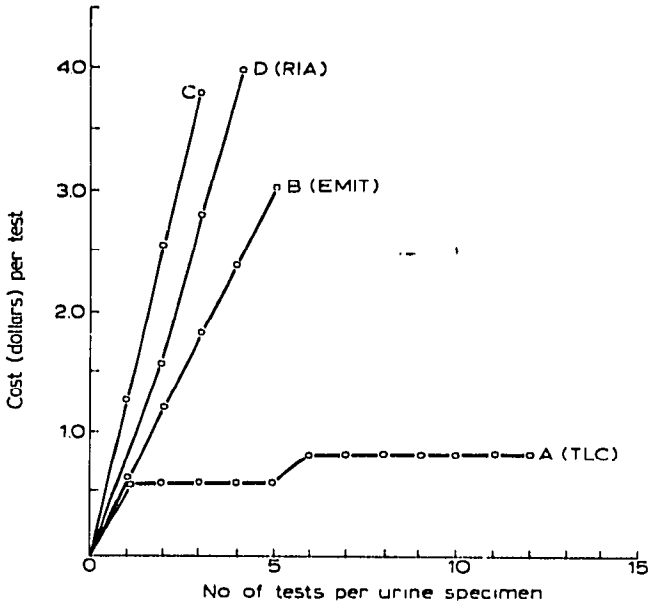

Fig. 2. Relationship between number of tests per urine specimen and cost per test. A, TLC; B, EMIT; C, RIA; D, RIA, showing that two tests (morphine and barbiturates) may be performed simultaneously using bivalent reagents (positives have to be re-done using monovalent reagents).

cost of testing a urine specimen for more than one drug increases according to the number of tests performed, thus a urine specimen will cost $3.0 for testing morphine, methadone, cocaine metabolite, amphetamine and barbiturate using EMIT and will cost more than $4.0 using RIA (see Fig. 2). Furthermore, the need to include standards, or to run various drug abuse calibrators, the necessity to confirm all positives by a non-immunological procedure or practical considerations such as repeating certain samples (to the extent of 20–30%) will substantially increase the total cost of analysis per specimen. These data also prove that no savings of tax payers' dollars can be achieved by replacing the personnel employed for performing TLC with automated immunoassay systems. In fact, using TLC techniques, we can have daily and speedy delivery of urine results by employing adequate staff and by adjusting the daily collection of urines according to the needs of a particular program. The readers are further advised that immunoassay techniques are unable to differentiate amphetamine from methamphetamine, phenobarbital from secobarbital and diphenylhydantoin (Dilantin), and morphine from codeine, and cannot detect amphetamine-type drugs such as phenmetrazine (Preludin), and methylphenidate (Ritalin), and sedative-hypnotics like glutethimide (Doriden).

ACKNOWLEDGEMENTS

The authors express their sincerest gratitude to the Management of Dangerous Drugs Commission, State of Illinois, for their keen interest and help in toxicology operations. They also wish to thank Jack Gilpin for his suggestions in the preparation of this manuscript and his keen interest in the operation of Toxicology Laboratories.

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