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Screening and semi-quantitative analysis of post mortem blood for basic drugs using gas chromatography/ion trap mass spectrometry

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Abstract

The study presented here shows that GC–MS with ion trap detection can be used for screening post mortem blood. The method described was used to simultaneously screen for unknowns, identify basic drugs present and semi-quantitate 14 drugs commonly encountered in coroner's toxicology (i.e. was used to determine whether the drugs were present in sub-therapeutic, therapeutic or greater than therapeutic amounts). The equipment used included a Varian Saturn 2000 GC–MS operating in full scan mode, a CP-3800 GC, a CP-8400 autosampler and Saturn GC–MS workstation Version 5.5 software. Post mortem blood samples were extracted using a standard liquid–liquid procedure; diethylether followed by back extraction into 0.1 M HCl. Standard curves for the 14 drugs which were semi-quantitated (amitriptyline, citalopram, clozapine, cocaine, cyclizine, diazepam, dihydrocodeine, dothiepin, methadone, mirtazapine, procyclidine, sertraline, tramadol, venlafaxine) were prepared covering the concentration range 0–1.0 ug/mL. The procedure is in routine use for coroners toxicology; semi-quantitation has been used (i) to speed-up the through put of cases where drugs are an incidental finding and (ii) for cases where the amount of sample submitted for analysis was too small to allow for screening, identification and quantitation on separate sample volumes.

Keywords: Post mortem blood; Ion trap GC–MS; Semi-quantitation

1. Introduction

Screening for basic drugs is part of any systematic toxicological analysis. The two major techniques used at present for such screening are HPLC coupled with diode array detection [1–3] and GC–MS using quadrapole mass selective detection [4]. LC–MS is used but because there are no reference spectral libraries it is only possible to identify drugs when standards have been run on the individual LC–MS, it cannot be used to identify "unknowns". This makes the use of LC–MS for systematic toxicological analysis at present limited. The separation power of capillary GC as well as the selectivity of the detection of MS, however, make GC–MS the technique of choice for systematic toxicological analysis [5,6]. Matching both the retention time and full scan spectra of an unknown peak with a standard is proof of identification.

The Toxicology Unit carries out casework on behalf of HM Coroners handling about 1200 such cases per year. For all cases where a drug screen is requested, a basic extract of the blood sample is screened by GC–MS. In the past this work has been carried out using the Hewlett-Packard quadrapole mass selective detector. The ion trap mass selective detector is reportedly more sensitive to possible matrix effects and saturation, which can cause the spectra to become distorted [7]. The aim of the investigation was to see if an ion trap detector could be used for routine systematic toxicological screening. Reviewing casework for 2003 showed that in the 1258 cases received, a total of 87 drugs were detected. There were 41 basic drugs, which were each identified in more than two

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cases during this period. To aid the detection and identification of these more commonly occurring drugs, the software was programmed to produce extracted ion chromatograms (EIC) from scan spectra to indicate the presence of these drugs. If a drug was indicated to be present, the full scan spectrum from the TIC was matched with a spectrum of pure standard run on the system. It is impossible to predict all the drugs it is possible to encounter in post mortem toxicology which means that any screening method used for coroner's work should be able to detect "unknowns". Although a drug history is usually provided, often drugs others than the ones specifically prescribed for the deceased are taken. Therefore, the mass spectrometer was operating in full scan so there was a total ion chromatogram (TIC) for each extract and the mass spectroscopist not only read the EICs but also systematically scanned the TIC for each case. In order to make the screening as efficient as possible the aim was to develop a method which could simultaneously screen for an unknown, unequivocally identify any basic drugs present and to semi-quantitate, that is to be able to say whether the drugs were present in sub-therapeutic, therapeutic or greater than therapeutic amounts from this initial screen. Reviewing casework for the previous year showed that there were 17 drugs detected with a frequency of more than once per month. These drugs were selected for semi-quantitation.

2. Materials

All chemicals/solvents were of analytical reagent grade and were obtained from VWR International Ltd (Poole, UK). Deuterated clomipramine was obtained from LGC Promochem (Hatfield, UK). All other drug standards were either from LGC Promochem or Sigma-Aldrich (Poole, UK). The DB-5 capillary column was from Crawford Scientific (Strathaven, Scotland).

Table 1
Correlation coefficients of regression (R^2) for standard curves and ion used for quantitation

Drug	Ion for quantitation	R^2 ($n = 6$)
Amitriptyline	58	0.9995
Citalopram	324	0.9998
Clozapine	243	0.9992
Cocaine	82	0.9993
Cyclizine	194	0.9958
Diazepam	256	0.9999
Dihydrocodeine	301	0.9936
Dothiepin	58	0.9999
Methadone	72	0.9999
Mirtazapine	195	0.9819
Procyclidine	84	0.9998
Sertraline	274	0.9979
Tramadol	58	0.9984
Venlafaxine	58	0.9993
d_3-Clomipramine (IS)	268	

2.1. Instrumentation

A Saturn 2000 GC–MS with a CP-3800 GC (Varian, Walton-on Thames, UK) fitted with a split/splitless injector port, and a CP-8400 autosampler (Varian) were used. The analytical column was a DB-5 (crosslinked 5% phenyl methyl siloxane, 30 m × 0.25 mm i.d., 0.25-μm film thickness) fitted with a retention gap (uncoated, deactivated) (1 m × 0.25 mm i.d., 0-μm film thickness). Temperature conditions were as follows: initial temperature of 50 °C for 2 min, increased to 180 °C at 30 °C/min, then increased to 280 °C at 5 °C/min and held for 19 min giving a total run time of 45 min. The flow of the carrier gas (helium) was maintained at 1.0 mL/min in constant flow mode. The MS was operated in full scan mode. The injector port was set at 280 °C. The GC–MS was programmed to perform a 1.2 μL splitless injection.

Data acquisition was performed using a Dell computer (Raheen, Ireland) fitted with Saturn GC–MS workstation Ver-

Table 2
Mean concentration and CV (%) for calibration standards ($n = 6$)

	Concentration (ug/mL)									
	1.0		0.5		0.2		0.1		0.05	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Amitriptyline	0.951	4.42	0.485	3.98	0.191	2.61	0.098	0.91	0.054	3.56
Citalopram	1.035	7.62	0.497	7.58	0.197	8.29	0.097	11.51	0.057	17.68
Clozapine	1.023	3.98	0.511	4.02	0.211	6.62	0.089	16.20	0.045	10.33
Cocaine	1.070	5.76	0.515	6.08	0.209	8.67	0.094	16.78	0.044	35.42
Cyclizine	0.927	5.32	0.525	3.92	0.245	8.97	0.138	20.73	0.027	40.27
Diazepam	0.978	4.96	0.468	4.95	0.168	8.04	0.095	13.99	0.060	14.07
Dihydrocodeine	0.994	6.62	0.428	6.25	0.215	7.66	0.091	17.13	0.078	20.27
Dothiepin	1.015	1.02	0.492	1.15	0.205	1.72	0.097	3.14	0.049	5.93
Methadone	1.023	2.92	0.504	2.41	0.194	1.58	0.097	3.68	0.055	8.30
Mirtazapine	0.940	4.19	0.536	4.26	0.274	5.39	0.091	14.64	0.026	36.32
Procyclidine	1.002	2.54	0.484	2.15	0.192	1.61	0.099	3.02	0.056	6.69
Sertraline	0.999	2.65	0.457	2.39	0.170	2.41	0.106	3.41	0.073	5.12
Tramadol	0.970	5.10	0.486	3.85	0.246	2.68	0.099	9.83	0.061	19.01
Venlafaxine	0.963	3.65	0.484	2.73	0.237	2.21	0.100	7.00	0.061	15.34

sion 5.51 software. The software was programmed to produce EICs from scan spectra for the specifically targeted drugs. Analytes were indicated to be present on the basis that retention time and relative abundance of each of the three target ions in the sample matched with the spectra produced from the pure standard. If a drug was indicated to be present, the full scan spectra from the TIC were matched with spectra of pure standards run on the system. The TIC was then systematically checked not only for the drugs indicated to be present by the EICs but also for any other significant peaks and for drugs mentioned in the history but not targeted by the EICs. If any compounds other than the 41 looked for by target analysis were found, the drug spectra were identified using the in-house library, Pfleger Maurer Webber library and the Wiley 275 library. If a drug was found that was not in the in-house library, pure drug standard was obtained and subsequently run on the ion trap GC–MS. All drugs reported had been matched both for retention time and full scan spectra with a pure drug standard run on the same machine. The maximum deviation in retention time allowed between drug in a sample and standard drug was 0.02 min. Samples were not derivatised because the screen had to be able to detect "unknowns" and neither the TFA nor silyl derivative libraries are complete.

2.2. Extraction of post mortem blood

After addition of internal standard (IS) (1 mL, 0.5 ug/mL clomipramine-d_3 in deionised water), post mortem blood (1 mL) was diluted with deionised water (3 mL), the samples was made basic (pH 10) by the addition of ammonia solution sp. gr. 0.880 (0.15 mL) and extracted with diethylether (6 mL). The diethylether was back extracted into 0.1 M HCl (5 mL). The ether layer was removed; the acid was made basic (pH 10) by the addition of ammonia solution sp. gr. 0.880 (0.15 mL) and re-extracted with diethylether (6 mL). After drying down at room temperature overnight, the final extract was reconstituted in acetonitrile (40 μL) and 1.2 μL was injected on the GC–MS.

2.3. Method validation

Both inter and intra-assay reproducibility of the screening method was monitored by running a 0.2 ug/ml solution of fluoxetine, amitriptyline, codeine and olanzapine in acetonitrile at the start and end of each run of routine case samples. These drugs have the following retention times and target/qualifier ions: fluoxetine, RT 12.35 min, ions 44, 104, 309, amitriptyline, RT 17.77 min, ions 58, 202, 217, codeine, RT 20.52 min,

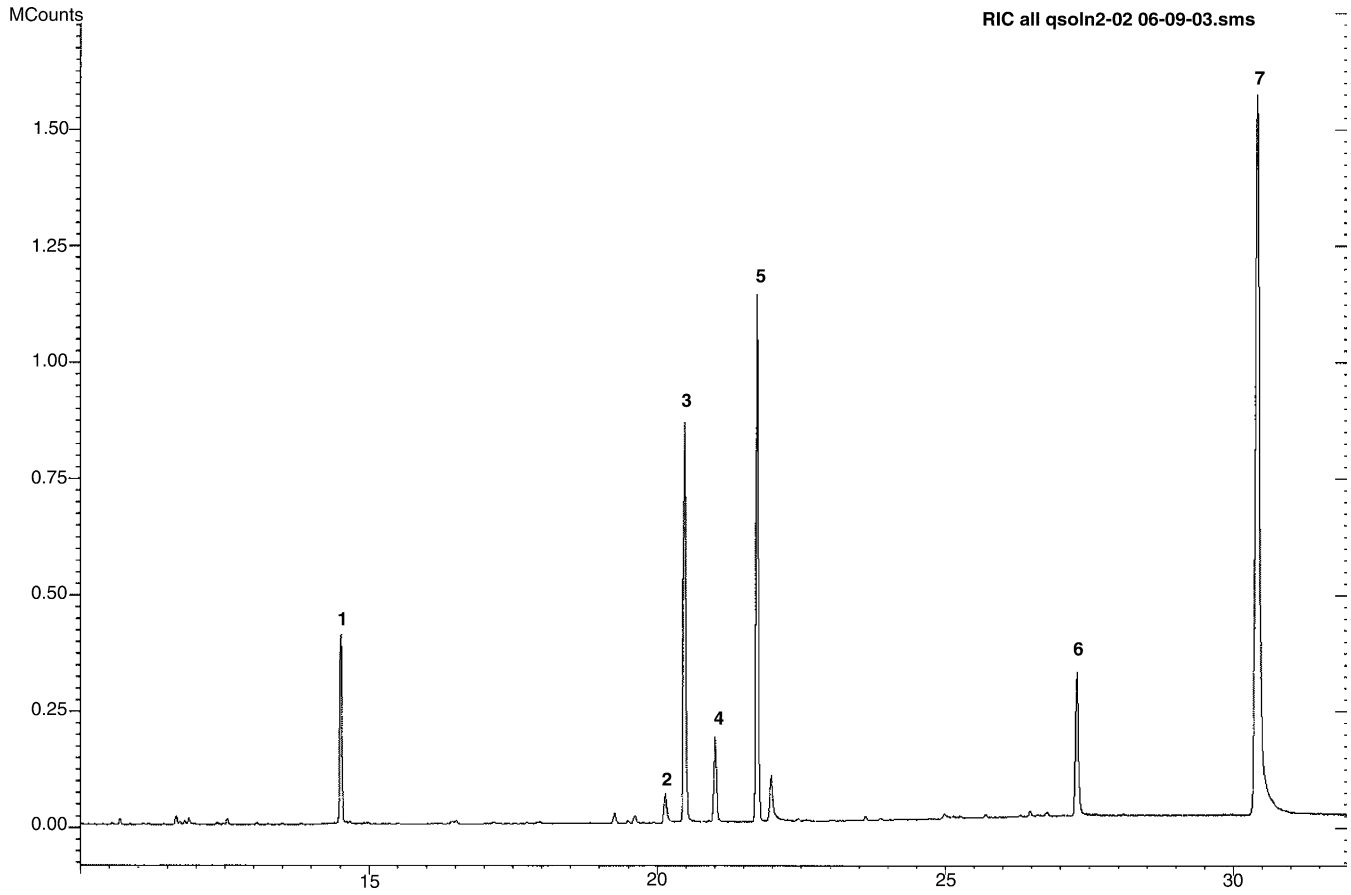

Fig. 1. Total ion chromatogram of a 0.2 ug/mL control solution. Peak indentification: 1, cyclizine; 2, dihydrocodeine; 3, clomipramine-d_3; 4, diazepam; 5, di-iso-octylphthalate; 6, clozapine; 7, cholesterol.

ions 299, 229, 162, olanzapine, RT 25.89 min, ions 242, 213, 312. The combination of these drugs checks the response of the mass selective detector throughout the run time and across the ion range. The limit of detection was determined by estimating the minimum concentration equivalent to, or greater than, three times the background noise while still allowing detection of all target ions.

2.4. Preparation of standard curves for semi-quantitation

Standard curves were prepared for 17 drugs, selected on the basis that they occurred on average at least once per month in casework. Four stock solutions were prepared containing each of the drugs listed below at a concentration of 1 mg/mL in methanol. Solution 1 contained methadone, amitriptyline, cocaine, citalopram, codeine; solution 2 contained cyclizine, dihydrocodeine, diazepam, clozapine; solution 3 contained procyclidine, mirtazapine, sertraline, dothiepin; solution 4 contained fluoxetine, tramadol, venlafaxine, paroxetine. Using these solutions standard curves were prepared. For each drug a 0, 0.05, 0.1, 0.2, 0.5 and 1.0 ug/mL standard in 1 mL of aqueous was prepared. To this IS (1 mL), blank blood (1 mL) and deionised water (2 mL) were added. The standards were then extracted using the same method as for post mortem blood extraction.

2.5. Method for semi-quantitation

Using the standard curve, a linear regression line equation ($y = mx + c$) was calculated. The Varian software (Saturn GC–MS Workstation v. 5.51) has the capability to store a method that includes the line equation and identification data that is the retention time and three target ions, for each drug. The concentration of a drug identified in a sample was calculated using this stored data.

2.6. Validation data for semi-quantitation

For 14 of the 17 drugs investigated the standard curves were linear over the concentration range 0–1.0 ug/mL. The ion used for quantitation and the correlation of coefficients of regression for each of these 14 drugs are shown in Table 1. The limit of quantitation was taken as the limit of detection which was the lowest standard, that is 0.05 ug/mL. At this concentration the signal to noise ratio was always greater than three times the background noise. The intra-assay reproducibility of the standard curves was shown by running six of each of the calibration standards. Table 2 shows the mean concentration and correlation coefficient for each of the calibration points. The inter-assay reproducibility is shown by running controls at concentrations of 0.2 and 1.0 ug/mL. The controls had to be within ±25% of the target value to be acceptable.

3. Results and discussion

Fig. 1 shows a typical chromatogram from a 0.2 μg/mL control solution which contained cyclizine, dihydrocodeine, clomipramine-d_3 (IS), diazepam and clozapine. Also shown are di-iso-octylphthalate, a plastizer (from the plastic tips, tubes, etc.) and cholesterol, which are co-extracted. Fig. 2 shows a typical chromatogram from a case which contained methadone (1.21 ug/mL) and cocaine (0.17 ug/mL). Table 3

Table 3
Retention times and mass spectral data used to produce EICs for specific drugs

Drug	Extracted ions (*m/z*)			
	RT (min)	Target ion	Qualifier 1	Qualifier 2
Amphetamine	5.92	44	91	65
Chlormethiazole	6.80	112	162	85
MDMA	8.73	58	135	194
Meconine	9.93	165	176	194
Propoxyphene artefact	10.09	193	130	208
Paracetamol	10.25	109	151	80
Pethidine	11.15	246	172	71
Fluoxetine	12.35	44	104	309
Diphenhydramine	12.41	58	165	152
Orphenadrine	13.63	58	181	165
Tramadol	13.30	58	135	262
Carbamazepine artefact	14.09	193	165	167
Chlorpheniramine	14.73	203	58	167
Cyclizine	14.90	194	208	99
Venlafaxine	15.69	58	134	91
Methadone	16.22	72	223	294
Propranalol	16.33	72	115	116
Procyclidine	16.73	84	204	205
Propoxyphene	16.89	58	193	208
Propranalol artefact	17.60	112	127	86
Amitriptyline	17.77	58	202	217
Cocaine	17.24	82	182	303
Trimipramine	18.02	58	249	234
Desipramine	17.99	235	194	44
Mirtazapine	18.00	195	180	222
Promethazine	18.54	72	180	213
Carbamazepine	19.46	193	236	165
Sertraline	20.02	274	276	239
Dothiepin	20.13	58	221	204
Codeine	20.52	299	229	162
Dihydrocodeine	20.36	301	284	244
Citalopram	20.49	58	238	324
Clomipramine-d_3	20.57	268	227	88
Clomipramine	20.67	58	269	229
Lamotrigine	21.06	255	185	257
Diazepam	21.11	257	285	221
Dipipanone	21.72	112	334	223
Chlorpromazine	21.94	58	318	272
Desmethyldiazepam	22.08	242	269	271
Chlordiazepoxide artefact	22.09	282	247	220
Oxycodone	22.26	315	230	316
Paroxetine	23.42	192	138	329
Midazolam	23.59	310	312	325
Olanzapine	25.89	242	213	312
Zolpidem	26.26	235	236	307
Chlordiazepoxide	26.66	282	283	284
Clozapine	27.28	256	192	244
Diltiazem	28.95	58	71	121

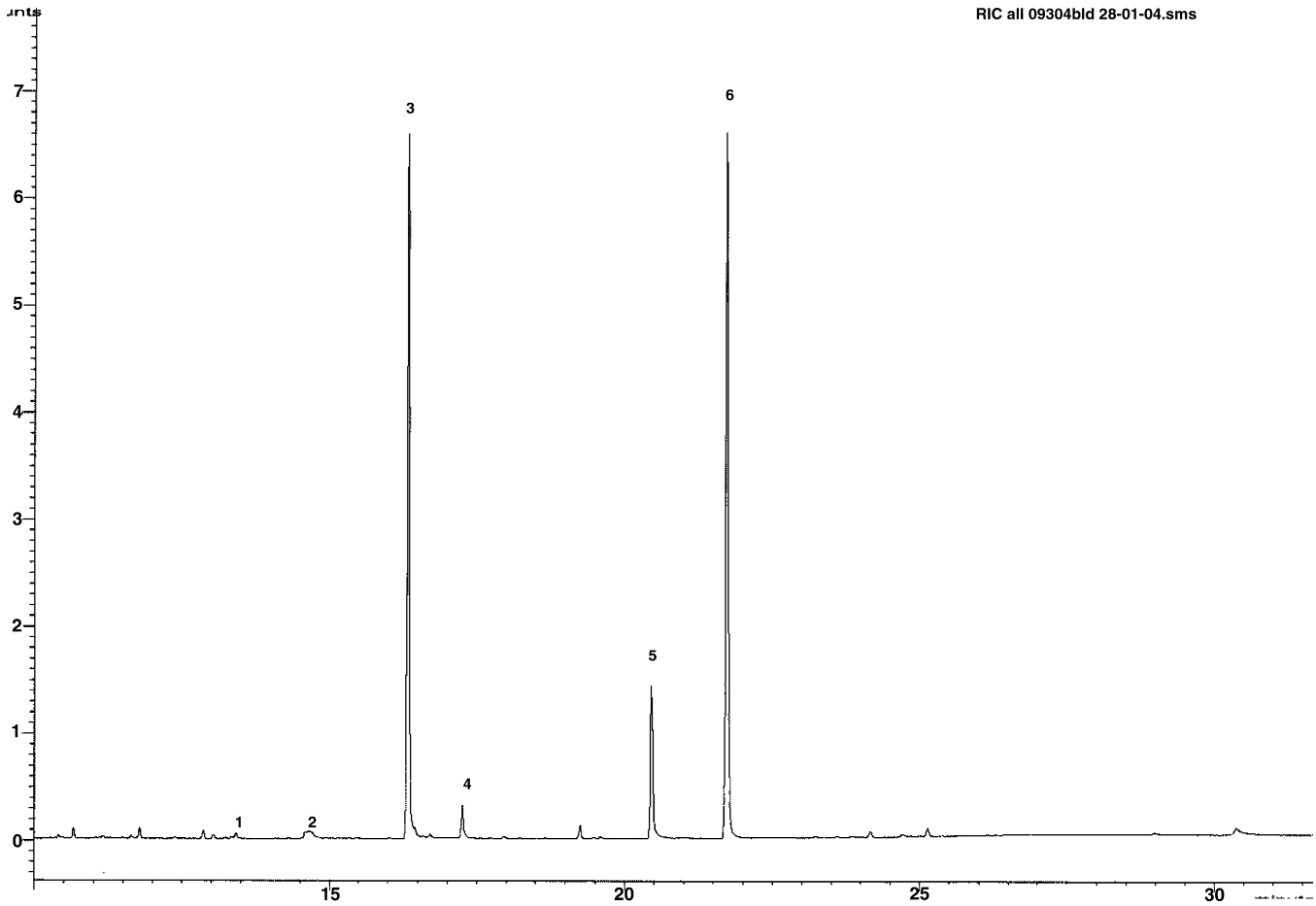

Fig. 2. Total ion chromatogram from a case. Peak indentification: 1, 2-ethyl-5-methyl-3,3-diphenylpyrroline (EMDP, a methadone metabolite); 2, 2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine (EDDP, a methadone metabolite); 3, methadone; 4, cocaine; 5, clomipramine-d_3; 6, di-iso-octylphthalate.

shows the retention times and mass spectral data used in the custom report to detect the EICs of 41 specific drugs. A print out was issued for each sample showing a chromatogram of the three selected *m/z* ions for each compound in a time window. If the EIC indicated the presence of a particular compound by showing that the ions were present in approximately the correct ratio and the retention time matched, the full scan drug spectra were checked with standard full scan spectra from the in-house library. Four of the drugs, propranolol, propoxyphene, chlordiazepoxide and carbamazepine break down on GC and for each drug a specific artefact was seen; the data for these artefacts has been included. Propoxyphene and carbamazepine occurred more frequently than once per month in casework but as they are thermo labile they were not suitable for semi-quantitation. Paracetamol has been included because although it is an acid drug in overdoses it is often there in such high concentrations that it will be detected even though the extraction is for basic drugs. Data for meconine has been included; meconine is a metabolite of noscapine which is a contaminant of street heroin. Meconine is often detected in the blood of heroin users and is useful for confirming the ingestion of street heroin.

Reviewing casework for 2003 also showed that there were 17 drugs detected with a frequency of more than once per month. These drugs were selected for semi-quantitation. For 14 of the drugs the standard curves were linear and reproducible but for the remaining three drugs, codeine, fluoxetine and paroxetine the lines were quadratic and were not reproducible. Only those drugs that gave linear standard curves and reproducible responses were semi-quantitated. If any of the drugs shown in Table 1 were detected then the concentration was calculated using the stored data. Each standard curve point was analysed six times and the mean peak area ratio value was used for the linear regression line equation in the calculations. If the amount of drug present was below or within its therapeutic range, then for cases where the drug had not contributed to the cause of death, the report actually stated “sub-therapeutic” or “therapeutic” amount and no full quantitation was performed for that particular drug. The numerical value was not stated because the measurement had not been obtained using the criteria normally used for quantitation, that is, the value must lie between the lowest and highest calibrators, controls must be within 20% and analysis, if sample volume allows, is performed in duplicate and these values must not vary by more than 20%. If the drug con-

centration was estimated to be greater than therapeutic then full analysis was performed if there was sufficient sample.

Table 4 shows the mean concentration and correlation coefficient for the controls used for the drugs which were semi-quantitated. These values were the mean of 6 which were run at regular intervals over 3 months. The results show that the standard curves were stable for at least this period of time. Although only 14 of the 17 commonly occurring drugs can be semi-quantitated, the remaining three were kept in the controls in order to monitor the limit of detection. If these three drugs were detected, full analysis was performed.

Table 5 shows the results for cases where the drug concentration has been obtained both by semi-quantitation and full quantitation. The methods used for full quantitation included both reverse phase and straight phase liquid chromatography with either diode array or UV detection and GC–MS. The method selected was determined by the particular drug combination in the case. For quantitation the standard curve range was typically 0.05–2.0 ug/mL; above this concentration the

Table 4
Mean concentration and CV (%) for controls ($n = 6$)

Drug	Concentration (ug/mL)			
	1.0		0.2	
	Mean	CV(%)	Mean	CV(%)
Amitriptyline	0.956	13.73	0.191	12.42
Citalopram	1.035	12.33	0.191	13.15
Clozapine	1.269	4.35	0.206	14.82
Cocaine	1.125	12.26	0.207	14.69
Cyclizine	1.138	19.29	0.255	19.33
Diazepam	1.112	19.92	0.220	19.71
Dihydrocodeine	0.871	7.74	0.150	19.24
Dothiepin	1.020	18.27	0.205	17.92
Methadone	1.059	14.21	0.227	13.10
Mirtazapine	0.992	4.20	0.213	21.52
Procyclidine	1.003	16.41	0.208	12.67
Sertraline	1.072	13.67	0.163	31.30
Tramadol	1.058	24.70	0.197	12.32
Venlafaxine	1.006	11.53	0.175	12.84

Table 5
Drug concentrations comparing result using semi-quantitation with result using full quantitation

Drug	Therapeutic range (ug/mL)	Concentration (ug/mL)		Method for full quantitation
		Semi-quantitation	Full quantitation	
Amitriptyline	0.05–0.20	1.70	1.72	RP HPLC
		0.88	0.92	RP HPLC
		5.85	6.63	RP HPLC
		0.34	0.34	SP HPLC
		3.10	2.98	GCMS
		0.39	0.46	SP HPLC
		0.81	0.83	SP HPLC
		0.08	0.09	SP HPLC
Citalopram	0.03–0.23	0.50	0.21	SP HPLC
		0.47	0.39	SP HPLC
		0.56	0.41	SP HPLC
		2.20	1.38	SP HPLC
		0.36	0.36	SP HPLC
Clozapine	0.10–0.80	2.54	3.22	RP HPLC
		0.62	0.56	RP HPLC
Cocaine	0.05–0.30	0.05	0.04	GCMS
		0.26	0.22	GCMS
		5.44	4.88	SP HPLC
		7.22	8.03	GCMS
		2.57	2.52	GCMS
		2.07	1.75	GCMS
Dothiepin	0.05–0.40	4.19	4.36	SP HPLC
		8.37	5.69	SP HPLC
		23.2	13.6	SP HPLC
Methadone	0.07–0.50	2.11	3.52	SP HPLC
		3.58	2.27	GCMS
Mirtazapine	0.02–0.1	0.65	0.51	SP HPLC
		0.28	0.16	SP HPLC
Sertraline	0.05–0.25	0.10	0.05	SP HPLC
		0.38	0.22	SP HPLC
Venlafaxine	0.25–0.75	25.56	25.03	GCMS
		0.23	0.22	SP HPLC

SP, straight phase; RP, reverse phase.

line often became curved due to saturation of the detector. Semi-quantitation was used as a guide to determine dilution to ensure the result fell within the range of the standard curve. Five results semi-quantitated to be within the therapeutic range and a venlafaxine result just below the therapeutic range were confirmed by full quantitation. For all but two cases, where the drug was present in greater than therapeutic amounts by semi-quantitation the result was confirmed by full analysis. For the two cases, one for citalopram and one for sertraline, the semi-quantitation suggested an amount greater than therapeutic but full analysis showed the result to be high therapeutic.

In 55 of the 586 cases (which is about 10%) submitted over a 6-month period in 2003 there was a definite cause of death found at autopsy such as hanging, or multiple injuries; these case were submitted for analysis because of the possibility of drug ingestion as well. The full breakdown for cases where there was a definite cause of death found at autopsy is shown in Table 6. In these cases if a drug was found and the concentration was within or below the therapeutic range that is if the drug was considered to be an incidental finding then the semi-quantitative result was reported and no full quantitation was performed. Table 7 shows the number of cases semi-quantitation was used for each drug. In some cases more than one drug was semi-quantitated. The advantage of semi-quantitation was that it speeded up the throughput of cases. This was particularly useful for cases where the Coroners would not release the body until analysis was complete.

Semi-quantitation was also useful for cases where the amount of sample submitted for analysis was too small to allow for screening, identification and quantitation on separate sample volumes. During a 6-month period in 2003 in about 8% of cases submitted for analysis only an ante mortem sample was available and this was typically no more than 1 mL in volume. These were mostly cases where the deceased had been hospitalised and had survived for several hours, in some cases for a matter of days. This made analysis of post mortem blood alone unsuitable. The majority of these samples were from road traffic accidents. In six of these cases drug was detected and the semi-quantitation result was used. The case type and drug semi-quantitated are summarised in Table 8.

The method described can be used for identifying the 41 drugs listed in Table 3, but no list used for screening can be complete. The method has detected basic drugs not specifically targeted including bupropion, clobazam, dextromethorphan, doxylamine, flecainide, ketamine, nefazadone, quetiapine, quinine, thioridazine, trazadone.

The ion trap is reportedly more sensitive to possible matrix effects and saturation, which can cause the spectra to become distorted [7]. This has not been our experience using post mortem blood. If the blood samples were not back extracted, fats and other co-extracted endogenous compounds could make the spectra more difficult to assign but it was still possible to get a positive spectrum match. This effect was a similar problem whether the mass spectra were acquired using a quadrapole or an ion trap analyser. Distortion of the spectra was only seen when a peak was overloaded. Even though the concentration of drugs detected during screening ranges from sub-therapeutic to fatal, distortion of the spectra was very rarely seen. It was more commonly encountered if stomach contents were analysed. The distortion occurs primarily at the apex of the peak, if the spectra towards either edge were used then the correct spectra were observed. This saturation of spectra at the peak apex again also occurred with the quadrupole detector. Also, just as with a quadrupole, the ion ratios of the unknown did not correspond exactly if

Table 6
Number of cases for each cause of death for cases submitted in a 6-month period in 2003 which were submitted for analysis "to exclude drug overdose"

Cause of death	Number of cases
Hanging	19
Multiple injuries	10
Natural causes	9
Self-inflicted stab wounds	3
Drowning	3
Diabetic crisis	2
Head injury	2
Plastic bag asphyxia	2
Epilepsy	1
Gun shot wound	1
Stabbing	1
Smoke inhalation	1
Burns	1
Total	55[a]

[a] Total number cases = 586 or 10% of cases.

Table 7
Number of cases for each drug where semi-quantitation was used in a 6-month period in 2003

Drug	Number of cases
Amitriptyline	1
Citalopram	11
Clozapine	1
Cocaine	10
Cyclizine	1
Diazepam	6
Dihydrocodeine	2
Dothiepin	2
Mirtazapine	9
Procyclidine	1
Sertraline	6
Tramadol	4
Venlafaxine	7

Table 8
Case type and drug semi-quantitated for cases where a limited am blood only was available over a 6-month period in 2003

Case	Drug	Result
Fall downstairs	Tramadol	Therapeutic
Overdose	Codeine	Therapeutic
Fall from height	Citalopram	Therapeutic
Fall from height	Diazapam	Sub-therapeutic
RTA (hit and run)	Dihydrocodeine	Therapeutic
RTA	Venlafaxine	Low therapeutic

RTA, road traffic accident.

the spectra were being matched with spectra in reference libraries, but if the compound had been run on the ion trap for the in-house library then ion ratios were seen to match. Fitzgerald et al. [8] reported that the spectra produced by the quadrupole and the ion trap for diazepam were very similar and it is our experience that the spectra were very similar for all the drugs.

No system or technique can be used to identify all drugs, complimentary techniques are needed. For example, certain benzodiazepines, including nitrazepam and temazepam, and certain antipsychotics, including risperidone, do not gas chromatograph; these drugs are analysed for by HPLC.

4. Conclusion

A method is described which can be used to simultaneously screen for basic drugs, positively identify any present and for 14 of the most commonly encountered drugs, a semi-quantitative result was obtained. The semi-quantitative results showed good correlation with the results from full quantitation. The Varian Saturn 2000 ion trap in full scan mode is suitable for the identification of unknowns.

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