The Contamination of Intravenous Fluid by Felt-Tip Marking Pen Ink: A Pilot Study

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ABSTRACT

Objective: The practice of writing directly on infusion bags with felt-tip marking pen was suggested to cause contaminations. Recommendation against such practice has been published by manufacturers and health care authorities. A chromatography-based laboratory experiment was conducted to substantiate the possibility of ink constituents permeation through Polyvinylchloride (PVC) infusion bag.

Methods: A Viaflex® intravenous infusion bag was marked with a blue Artline® marking pen ink. Fluid samples were obtained at different time intervals and tested for any contaminations. A gas chromatography with mass spectrometry capability system was used to analyse fluid samples from infusion bag.

Results: Five fluid samples were obtained from the infusion bag at 0, 10, 30, 60, 120 minutes after ink exposure. Chromatograms from each sample were compared with a chromatogram from "blank" intravenous solution. There appeared to be no chromatographic evidence of ink constituents present in all intravenous fluid samples.

Conclusion: The practice of writing directly on Viaflex® infusion bags with a felt-tip marking pen has not resulted in contamination of intravenous fluid by ink constituents.

Keywords: Ink; marking pen ink; pilot study (Siriraj Med J 2018;70: 349-354)

INTRODUCTION

The practice of writing on plastic infusion bags for labelling purpose has been suggested to cause contaminations from chemicals in the ink. Several official statements and recommendations regarding the issues have been published and followed by healthcare providers.[1,2,3] Nevertheless, extensive literature review has not revealed any substantiated study which proved the statements to be true. However, the study of acute toxicity of marking pens on mice found: marking pen produced respiratory toxicity and neurobehavioral changes including abnormal posture and gait, tremors, falling, and/or hyperactivity, facial swelling, severe lacrimation and gasping.[4] Two previous studies could not demonstrate penetrations of ink chemicals through infusion bags, though limited by studies' design.[5,6] As abandoned by many practicing healthcare providers as a routine practice, writing directly on infusion bags might come to benefit in managing fluid and drug administration in emergency situations or in mass casualties.

The purpose of this study is to conduct a chromatography-based experiment to prove whether or not the plastic (PVC) infusion bags are permeable to chemicals from felt-tip marking-pen inks and cause contaminations.

MATERIALS AND METHODS

Study was conducted at the Toxicology laboratory located in Siriraj Hospital, Mahidol University, Thailand. Gas chromatography system with mass spectrometry

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capability (GC-MS) (Agilent® 7890A, Agilent Technologise, Inc., California, USA) was used for analysis.

ArtLine® felt-tip (Artlink Co., Ltd., Wangthonglang, Bangkok)marking pens, commonly used in the department of Anesthesia and more chemicals than other brands, were chosen for the study. A 99.99% HPLC-grade methanol and 99.9% purified NaCl were used in sample preparation. Specific infusion containers analysed were 250 ml Baxter® Viaflex 0.9% Sodium chloride intravenous fluid bag .The bag is 0.031 mm thick, composition and concentration of Na + 154 mmol/L and Cl- 154 mmol/L, total osmolarity is 308 mOsmol / L and pH 4.5-7. The Baxter® Viaflex, a type of specially formulated polyvinyl chloride (PL 146 plastic) that is widely used in intravenous solution container products, might have permeability to moisture and can interact with solutions to cause contaminations.[1,7,8]

GC-MS setup and reference solution preparation

Blue ArtLine® felt-tip marking pen ink was painted on Baxter® Viaflex 0.9% Sodium chloride bag to cover an area of 1 cm (width)*1 cm (length). The ink-covered area was cut and then soaked in 1 ml of 99.99% methanol to prepare a stock solution with a concentration of 100 unit (cm^3/ml); a 100 unit concentration stock solution merely contained the amount of ink possibly be painted in one layer to cover a one centimetre area. This stock solution was; intended to use for calibrating and standardising the analysis process, not for comparing or measuring as amount of ink. The stock solution was preserved in -20°C and sequentially diluted to 10, 5, 1 and 0.1 unit%. The stock and dilute solutions were incubated in 80°C and extracted by solid phase micro extraction technique (SPME fiber: divinylbenzene / Carboxen/ PDMS, Supelco®). Samples were injected into GC-MS system, and chromatograms were obtained from each sample of different concentrations.

The extraction and analysis of samples were carried out with CTC combi AAL auto sampler equipped with agitator and needle heater (for fiber conditioning and inter – extraction clean up coupled to a GC-MS (Agilent Technologics 7890A system)) and operated in the split/ splitless mode at an injection temperature of 250°C. The separation of target analytes were achieved on a DB-WAX fused capillary column 30 m x 0.25 mm i.d. x 0.25 µm film thickness. Helium (carrier gas) was set to a constant flow rate of 1 ml/min with linear velocity of 40 cm/s. The GC column oven temperature program was set as follows. Initially set at 40°C for 3 min, ramped at 10°C/min to 100°C, then ramped to 250°C at 25°C/ min, and held for 5 min. The MS operation condition includes transferline of 250°C, ion source of 230°C. electron ionization (EI) of 70 eV.

Although not the study's objective; chromatograms were compared with standard database (NIST Library and FT5 library) for identification of ink chemical constituents. Chromatograms from 100, 10, 5, 1 and 0.1 unit solutions showed identical patterns, which implied that the GC-MS analyses were consistently sensitive and accurate within the concentration range. Any amount of ink constituents found within the range of 0.1 to 100 unit concentrations would be accurately reported.

Chromatograms obtained from 0.9% Sodium chloride "blank" solution (250 ml Baxter® Viaflex bag) and from 0.1 unit% solution were used as references to compare with study samples.

Study samples preparation and analysis

Six samples of 250 ml Baxter® Viaflex 0.9% Sodium chloride bag was painted with Blue ArtLine® felt-tip marking pen ink in one layer to cover a 5 cm* 10 cm area. (Fig 1). If the bag allowed total penetration of ink constituents into the solution, it would result in a 0.2 unit (cm^3/ml) solution. Sample solution (5 ml) was aspirated immediately through aspiration port after the infusion bag was exposed to the blue ink, and 5-ml samples were aspirated on intervals of 10, 30, 60 and 120 min of exposure time.

Solutions aspirated from the bag were incubated in 80°C, followed by micro extraction technique using same SPME fiber.

If ink constituents were present in the solutions, it would be extracted into the fibers and detected by GC-MS.

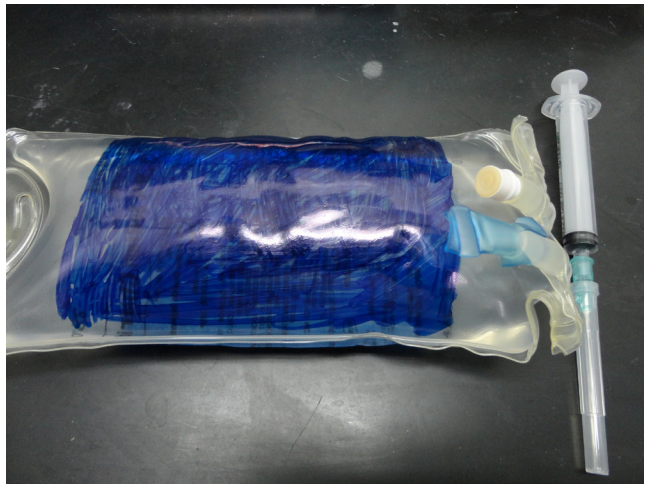

Fig 1. Felt-tip pen ink covered Viaflex bag.

RESULTS

A reference chromatogram from 0.1 unit% solution consisted of 62 peaks, which represent 62 different constituents found in the blue Artline felt-tip pen. NIST and FT5 data base analysis could identify some, but not all the constituents (Fig 2).

Five fluid samples aspirated from different time intervals (0, 10, 30, 60 and 120 min) were analysed with GC-MS and were compared with the chromatogram from 0.9% "blank" sodium chloride solution (Fig 3).

The results showed identical chromatographic patterns of each sample from different time intervals, and they were identical to "blank" 0.9% sodium chloride solution (Fig 4).

There appeared to be no chromatographic evidence of contamination from exposing the bag to blue Artline felt-tip marking pen at 0, 10, 30, 60 and 120 min exposure time.

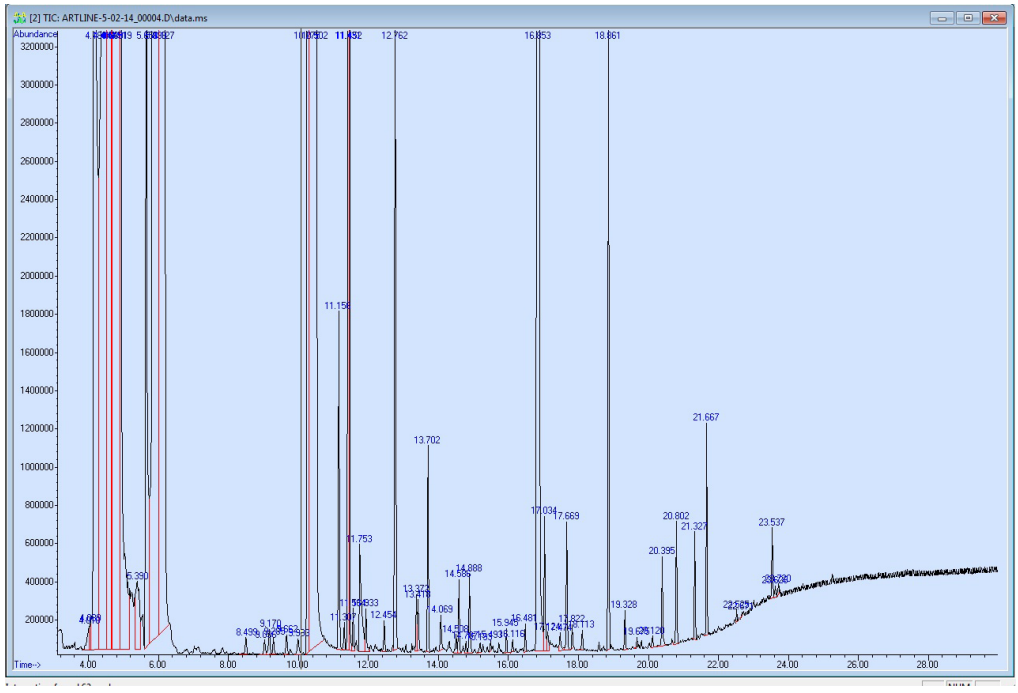

Fig 2. Chromatogram from reference sample.

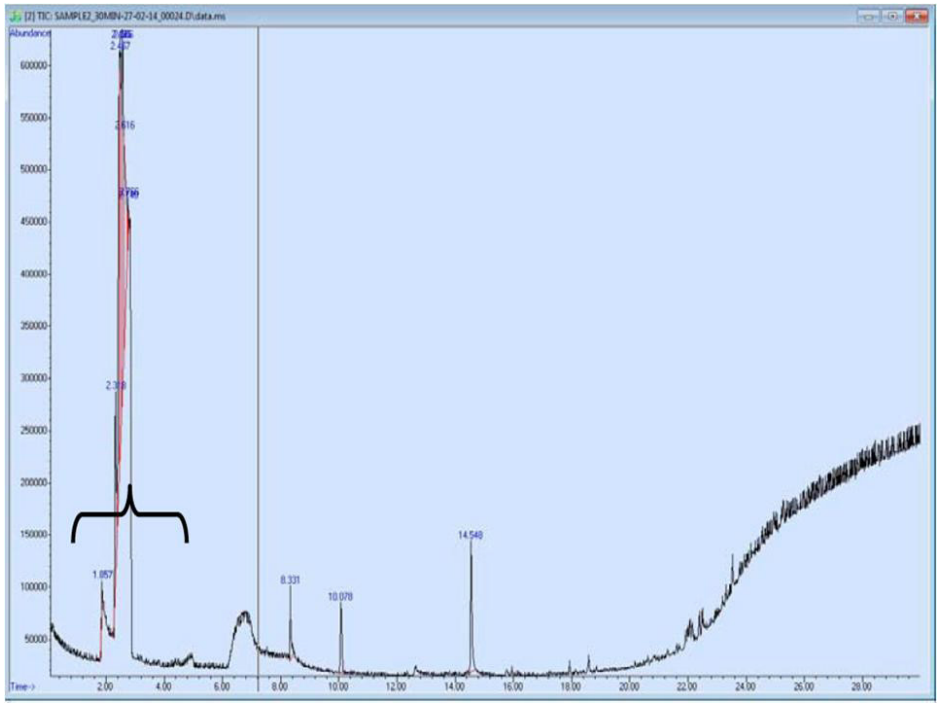

Fig 3. Chromatogram from "blank".

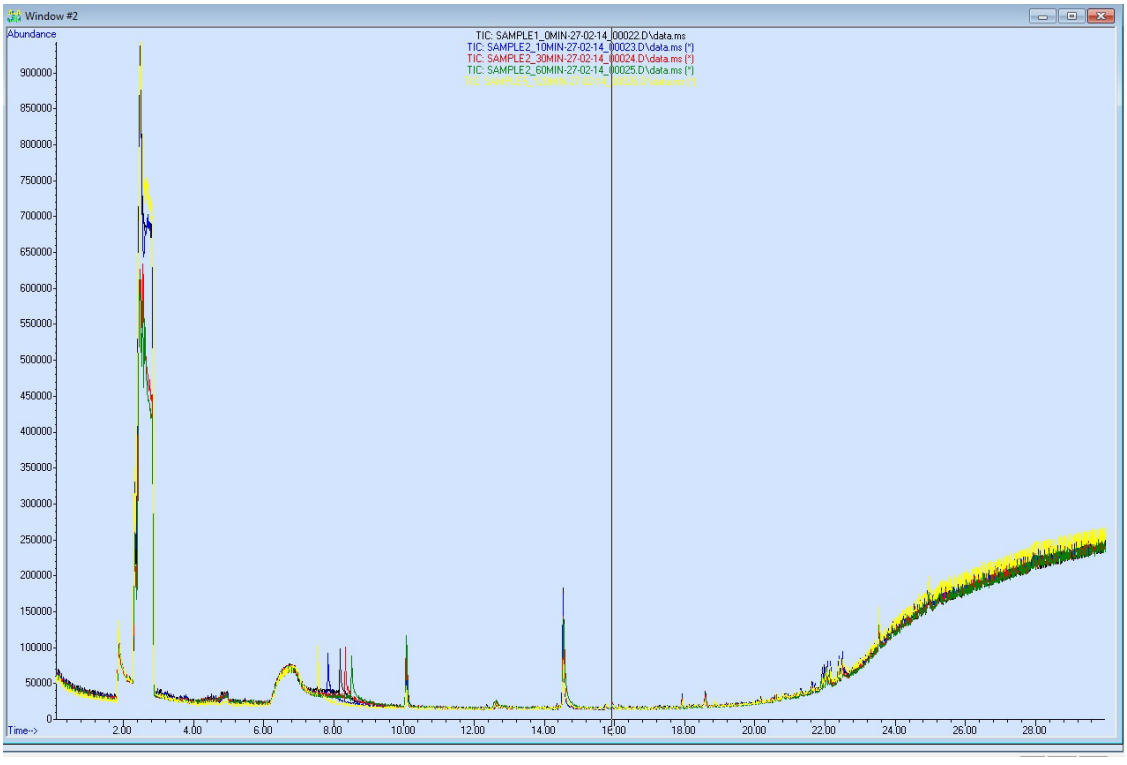

Fig 4. Comparison of chromatograms from different time intervals.

DISCUSSION

The purpose of the present study was to indicate whether the practice of writing directly onto PVC intravenous containers with felt-tip marking pen would cause contaminations from ink constituents.

The Viaflex bag used in the experiment was manufactured from the Baxter formulation of polyvinylchloride (PVC) known as PL146 Plastic. PVCs might have permeability to constituents used in felt-tip marking pen ink such as alcohol compound solvents.

Previous studies and recommendations were based on the hypothesis that alcohol compound or volatile substances in marking pen inks are permeable to the PVCs containers. The present study was the first to use highly sensitive GC-MS analysis to prove the hypothesis. List of ink constituents are shown in Table 1.

Limitations to our study include limited number of intravenous fluid containers and felt-tip marking pen. The types of container and pen were conveniently chosen as they are generally used in Siriraj Hospital's Department of Anesthesiology.

Although GC-MS analysis is one of today's most sensitive test to identify substances, the accuracy depends largely on meticulous sample preparation process and standardised GC-MS setup.

The toxicology laboratory guaranteed results to be accurate within the range of standard sample preparation (100-0.1 unit). If the ink constituents are present in smaller amount than GC-MS setup, it would not be detected accurately. The sensitivity of GC-MS setup could be increased, but it was the authors' opinion that the chosen setup was sufficiently sensitive to prove the hypothesis.

The authors chose a 5 cm* 10 cm ink-covered area to be tested because it contained much larger amount of ink used in real-life practice. If the intravenous container was proven to be resistant from contaminations in the experiment, the container in real-life situation having exposed to much lesser amount of ink would likely to be resistant as well.

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Conflict of interest: No conflict of interest declared

Financial disclosure: No source of financial support

TABLE 1. Ink constituents analysed from database.

Ink constituents analysed from database							
No.peak	**Rt**	**Library**	**Result**	**No.peak**	**Rt**	**Library**	**Result**
1	4.009	FT5	No matches found	32	13.701	W9N11	Benzaldehyde diethylacetal
2	4.038	FT5	No matches found	33	14.069	W9N11	Silanediol, dimethyl
3	4.181	W9N11	Ethanol	34	14.509	FT5	No matches found
4	4.419	W9N11	Ethanol	35	14.586	FT5	No matches found
5	4.645	W9N11	Ethanol	36	14.789	FT5	No matches found
6	4.663	W9N11	Ethanol	37	14.890	FT5	Phenylacetamide
7	4.799	W9N11	Ethanol	38	15.193	W9N11	Acetic acid, phenylmethyl ester
8	4.918	W9N11	Ethanol	39	15.490	FT5	Pyrilamine
9	5.388	FT5	No matches found	40	15.942	FT5	No matches found
10	5.650	W9N11	1-Propanol	41	16.115	W9N11	Benzenemethanol
11	5.899	W9N11	1-Propanol	42	16.483	FT5	Carbamazepine-M (formyl-acridine)
12	6.125	FT5	No matches found	43	16.852	W9N11	Benzyl alcohol
13	8.498	FT5	Dichlorophene TMS	44	17.036	FT5	No matches found
14	9.033	FT5	No matches found	45	17.125	W9N11	Butylated Hydroxytoluene
15	9.170	FT5	Dimethadione	46	17.476	FT5	Carisoprodol
16	9.283	FT5	No matches found	47	17.666	W9N11	Cyclododecane
17	9.663	W9N11	Cyclohexanone	48	17.210	W9N11	2-tert-Butyl-4-5-dimethylphenol
18	9.996	FT5	No matches found	49	18.112	W9N11	phenol
19	10.279	FT5	No matches found	50	18.862	W9N11	Ethanone,1- (2,3,4-trimethylphenyl) 1-1 (2,3,4-trimethylpheyl) ethanone
20	10.502	FT5	No matches found	51	19.331	FT5	Cyclandelate TMS
21	11.156	FT5	No matches found	52	19.676	FT5	Meprobamate
22	11.304	FT5	No matches found	53	20.122	FT5	No matches found
23	11.429	FT5	No matches found	54	20.396	FT5	Phenylethylamine,Beta
24	11.453	FT5	No matches found	55	20.800	W9N11	Phenol,p-tert-butyl-phenonl
25	11.566	W9N11	Propanolic acid 2- (1-ethoxyethoxy)	56	21.329	FT5	No matches found
26	11.750	W9N11	Acetic acide	57	21.668	FT5	No matches found
27	11.935	FT5	Dichlorophene	58	22.524	FT5	No matches found
28	12.452	W9N11	1,2.,4-Methenoazulene,decahydro-1	59	22.673	W9N11	1,4,7,10,13,16-Hexaoxacyclooctadec
29	12.761	W9N11	Benzaldehyde	60	23.535	W9N11	Phenol,4- (1,1,1,3,3-tetramethylbutyl
30	13.373	W9N11	Junipene	61	23.624	FT5	No matches found
31	13.415	W9N11	Naphthalene,1,2,3,5,6,8,8a-octa hydro-18a-dimethyl-7-(1-methylethenyl)	62	23.719	FT5	No matches found

What is already known on this topic

The use of felt-tip marking pens to label PVC intravenous fluid containers has been prohibited by several healthcare authorities in concern of the contamination of ink substances into the intravenous fluid to be given to patients.

What this study adds

Highly sensitive gas chromatography and mass spectroscopy analysis could not detect the contamination of ink material when using felt-tip marking pens to label Viaflex® intravenous fluid bags.

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