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*Corresponding author

*Dr. Nabil Abu-Amer, MD,Institute of Nephrology and Hypertension
Sheba Medical Center
Tel Hashomer, Israel 52621
Tel. 972-3-5302581, FAX 972-3-5302582
Email: Nabil.Abu-Amer@sheba.health.gov.il

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Case report

Acute kidney injury following exposure to a formaldehyde –free hair straightening products

Nabil Abu-Amer [1], MD, Natalie Silberstein [2], MD, Margarita Kunin [1], MD, Sharon Mini [1], MD, Pazit Beckerman [1], MD

Institute of Nephrology and Hypertension, Sheba Medical Center, Sackler School of Medicine, Tel Aviv University, Israel

Abstract

Formaldehyde- free hair straightening products are hair smoothening solutions widely used by professional beauty salons. Formaldehyde-free hair straighteners do not technically contain formaldehyde, however they contain other chemicals such as glyoxyloyl carbocysteine which releases formaldehyde upon contact with heat. Moreover, its by-product glyoxylate may convert to oxalate, both compounds have potential nephrotoxic effect.

Case presentation:

41-year-old woman presented to the emergency room with weakness, nausea , vomiting and stage three acute kidney injury according to Kidney Disease: Improving Global Outcomes acute kidney injury staging (KDIGO) shortly after exposure to formaldehyde - free hair straightening product, other causes of acute kidney injury were excluded such as preceding acute illness, drug history or others nephrotoxic agent exposure On physical examination the patient was pale, her vital signs were normal. The urine microscopy and serologic workup was not indicative. Kidney core biopsy reveal interstitial edema, acute interstitial nephritis and oxalate crystal nephropathy. Kidney function completely recovered after a short course of steroid therapy.

Conclusions:

We present a case of severe kidney injury after exposure to hair straightening products

branded as formaldehyde free but actually contain other chemicals products which release

formaldehyde and other toxic chemicals when heated during the straightening procedure and may cause systemic toxicity, particularly kidney injury. Different cosmetic products are widely in use, not all are under a tight regulation, and therefore it is important to raise the awareness of both medical teams and consumers of possible adverse health effects of different cosmetic products.

Introduction

Nephrotoxicity is defined as kidney injury due to toxic effects of chemicals. There are various forms of chemicals and drugs that may affect renal function in various mechanism including acute tubular necrosis (ATN), tubulopathy and electrolyte imbalance, acute interstitial nephritis (AIN), glomerular damage, crystal nephropathy, and thrombotic microangiopathy [1-3].

Formaldehyde- free hair straightening products contain potentially toxic chemicals other than formaldehyde. One potential such substance is glyoxyloyl carbocysteine, which is composed of glyoxylic acid, cysteine and acetic acid. Glyoxylic acid both releases formaldehyde when heated and is converted into either glycine by AGT1 (alanine:glyoxylate aminotransferase 1) or oxalate by glycolate oxidase in the human cell peroxisomes [4].

Formaldehyde is a colorless aldehyde poisonous gas at room temperature [5]. It is usually mixed with water and when the small fraction of soluble

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formaldehyde reacts with water, it quickly forms methylene glycol. For every molecule of free formaldehyde, 1,820 molecules of methylene glycol are formed [6]. Methylene glycol reverts back to free formaldehyde almost immediately upon contact with air or skin. Formaldehyde is thus absorbed through skin, eyes, and inhalation, and is eliminated through the urine [7-8]. During the hair straightening process, high levels of formaldehyde are found in samples of air taken from beauty salons [9] and in specimens of hairstylist workers skin [10-11].

In the kidney, formaldehyde has been reported to cause direct cytotoxic effect resulting in acute toxic tubular necrosis [12-13], and may also cause an immune system response leading to acute interstitial nephritis.

Another potential nephrotoxic component of hair straightening products is oxalate, which is an end product of glyoxylic acid. Increased levels of oxalate promote calcium oxalate precipitation in various tissues including the kidneys, resulting in toxic injury.

Case presentation

A 41-year-old woman with a history of hypothyroidism and sleeve gastrectomy five years ago, presented to the emergency department with profound weakness, nausea and vomiting. Her symptoms began three days earlier, immediately after using a professional hair straightening formaldehyde- free product in a professional beauty salon.

On physical examination the patient was pale, her vital signs were normal, heart rate was 66 bpm, blood pressure was 125/70 mmHg, she had no fever or respiratory distress and appeared euvolemic.

Laboratory investigations revealed a serum creatinine of 3.46 mg/dl (one year prior to the event Cr. value was 0.6 mg/dl), urea 77 mg/dl, and electrolytes, liver function tests, Beta human chorionic gonadotropin (β-hCG) and complete blood count were normal. Blood venous gases revealed: pH 7.375, HCO3 21 mmol/L and base excess 3 mmol. The anion gap and serum osmolar gap were normal. Urinalysis demonstrated leukocyturia +1 without hematuria or proteinuria.

During hospitalization urine output was normal, repeat urinalysis demonstrated leukocyturia +1 without hematuria or proteinuria, and Bence-Jones protein was negative. Urine microscopy demonstrated epithelial cells with few white blood cells without any casts or crystals. Renal ultrasound showed 14.4 cm bilateral echogenic, edematous renal parenchyma (shown in Fig. 1).

A full serologic workup including hepatitis B and C, Human immunodeficiency virus (HIV), syphilis, antinuclear antibody (ANA) , Anti-double stranded DNA, Antineutrophil cytoplasmic antibody (ANCA), Anti-Phospolipid antibody (APLA) was normal except for a complement C3 level of 80 mg/dl (normal range 90-110 mg/dl).

On the 4th hospitalization day a renal core biopsy was performed. The histologic examination (shown in Fig. 2) was correlatd with acute tubular necrosis, tubulo- intersitial nephritis and oxalate crystals . With the diagnosis of interstitial nephritis, the patient was started on prednisolone 1 mg/kg, one week later serum creatinine decreased to a level of 0.98 mg/dl.

Discussion

This patient presents an unusual case of kidney

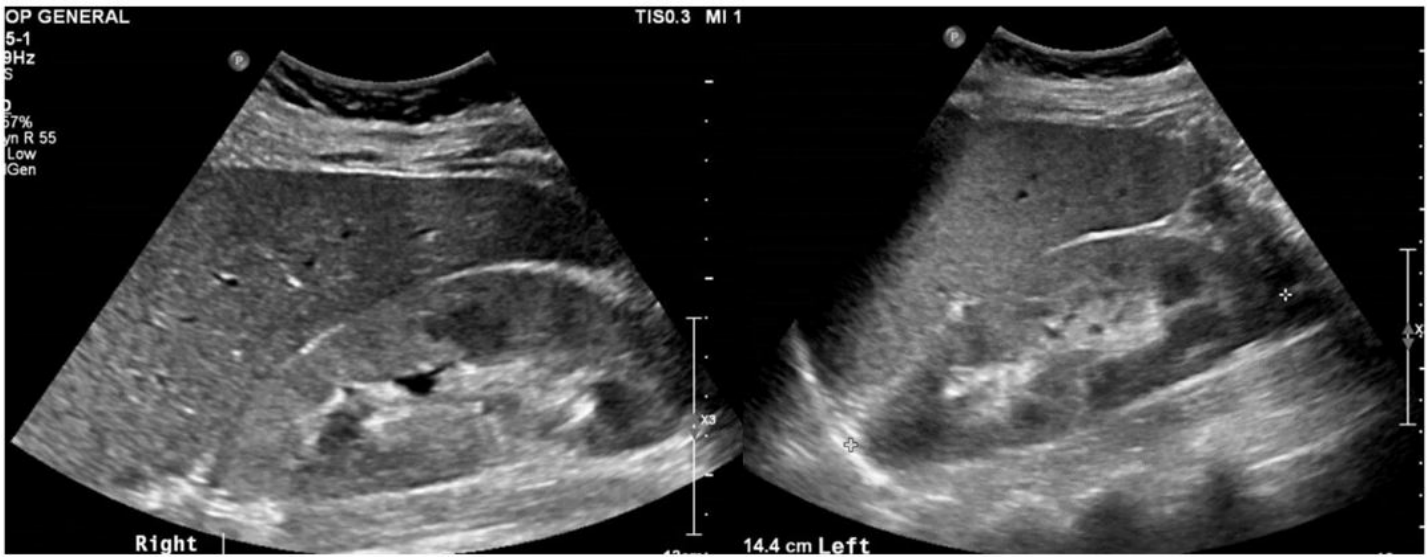

Figure 1: *Bilateral enlarged kidneys (14.4 cm) with echogenic, edematous parenchyma.*

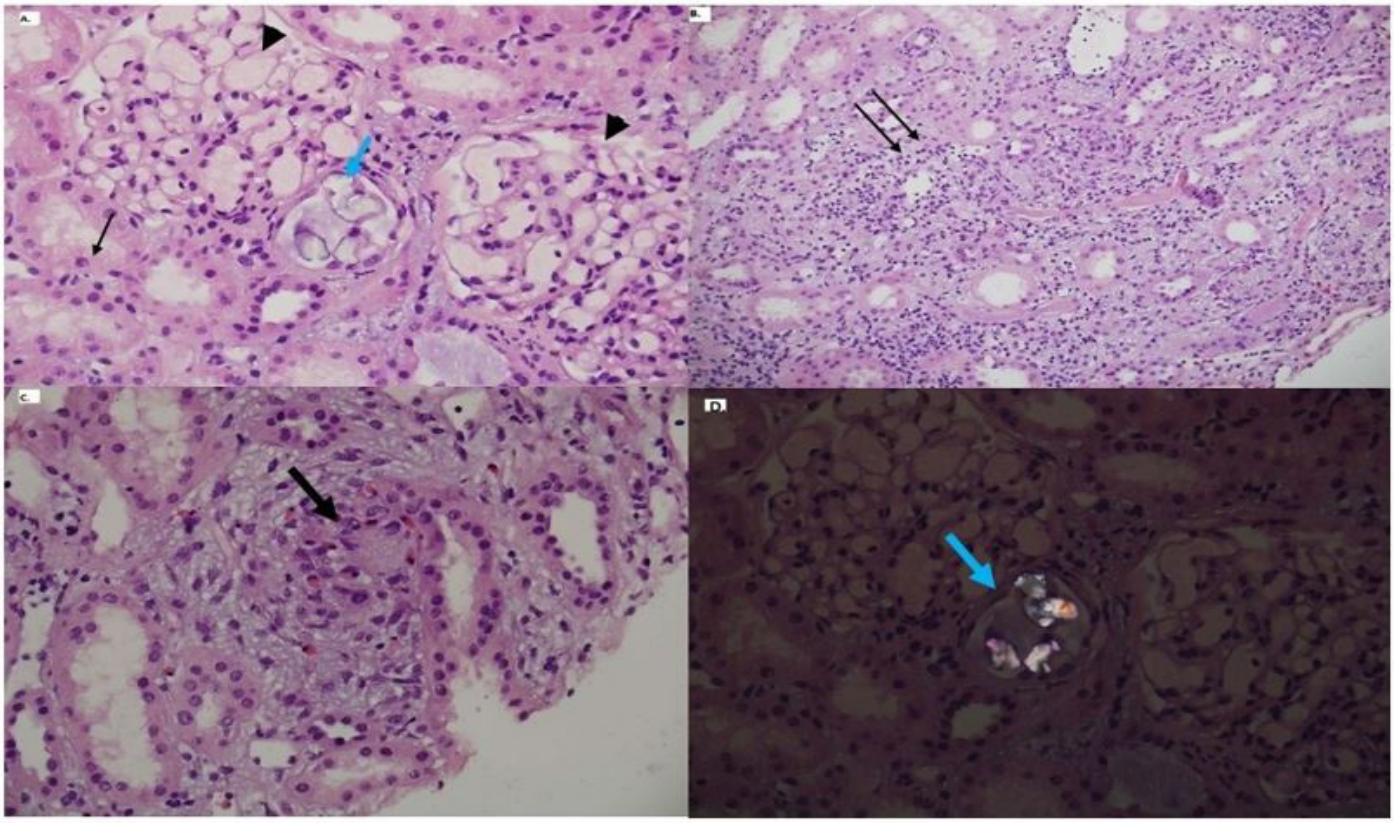

Figure 2: *Kidney core biopsy: Hematoxylin and eosin staining;*
A*: Glomeruli were normo-cellular and without signs of active glomerular disease (arrow heads), tubules showed signs of diffuse tubular injury (black arrow) and tubules contained oxalate crystals (blue arrow).*
B*:The interstitium showed edema associated with multifocal mixed inflammatory infiltration with multiple eosinophils and foci of tubulitis.*
C*:There was one epithelioid granuloma.*
D*:Tubules contained oxalate crystals (blue arrow) observed under polarized light-microscopy. Immunofluorescence analysis revealed C3 1+ in blood vessel walls only.*

toxic and inflammatory injury accompanied with oxalate deposition secondary to hair straightening product. In a literature review, only few cases [14-15] of acute kidney injury (AKI) following hair straightening formaldehyde- free product exposure were reported. All cases were reported after 2019. The spectrum of kidney injury following hair straightening ranges from mild to severe kidney injury requiring renal replacement therapy. The histopathologic changes reported mainly depicted severe acute tubular necrosis and acute interstitial nephritis.

Our patient presented with stage 3 AKI following hair straightening formaldehyde - free product exposure. Other causes of AKI were excluded such as preceding acute illness, drug history or other nephrotoxic agent exposure. Laboratory workup revealed leukocyturia +1, and ultrasonography was significant for enlarged edematous echogenic renal parenchyma. Kidney biopsy demonstrated acute interstitial nephritis, oxalate crystal precipitation and acute tubular necrosis. We speculate that the clinical presentation and the histopathologic changes directly resulted from exposure to the hair straightening formaldehyde- free product.

In reviewing the ingredients of the specific product used in this case, it included

glyoxyloyl carbocysteine, glyoxyloyl keratin amino acid, propylene glycol glycerin, phenoxyethanol, ethylhexylglycerin disodium and other collagen, surfactant and fragrance components. We did not find evidence in the medical, pharmacological and chemical literature that any of these substances causes acute kidney injury other than glyoxyloyl carbocysteine.

Many hair straightening products are labeled as formaldehyde "free" but actually contain chemicals such as glyoxyloyl carbocysteine or methylene glycol which release formaldehyde and other toxic chemicals when heated, e.g the carbocysteine hair treatment represents the combination of glyoxylic acid + cisteine + acetic acid. Glyoxylic acid contains an aldehyde functional group, glyoxylic acid behaves as an aldehyde by heating during

the hair straightening process thus releasing high levels of formaldehyde gas exceeding the capacity of exposure[16]. On top of that, glyoxylic acid absorbed through the scalp may had converted to oxalic acid [17] which may precipitate in kidney tissue. It is possible that other components such as propylene glycol may cause osmotic renal injury. In this case, serum osmotic gap was not available since it calculated four days after exposure.

Conclusion

In conclusion, a case of severe kidney injury after exposure to hair straightening products branded as formaldehyde free is presented. This case highlights the sensitivity of the kidney to various environmental and commercial products, some of which have not been fully characterized or identified yet.

It is important to raise the awareness of both medical teams and consumers, of possible adverse health effects of different cosmetic products, including acute kidney injury, and perhaps promote tighter regulation of such products.

Statement of Ethics

Ethical approval is not required for this study in accordance with local or national guidelines.

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available.

Conflict of Interest interests

The authors have no conflict of interest to disclose

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Authors' contributions

NAA, NZ, SM, PB, were involved in the clinical management of the patient.

NAA, MK, collected the data and wrote the first version of the manuscript.

NAA, NZ, MK, SM, PB approved the final version of the manuscript.

The authors read and approved the final manuscript.

Data Availability

All data that support the findings of this study are included in this article

References

1. Vormann MK, Gijzen L, Hutter S, Boot L, Nicolas A, van den Heuvel A et al. Nephrotoxicity and kidney transport assessment on 3D perfused proximal tubules. AAPS J. 2018;20:90
2. Frazier KS, Obert LA. Drug-induced glomerulonephritis: The spectre of biotherapeutic and antisense oligonucleotide immune activation in the kidney. Toxicol Pathol. 2018;46:904–17
3. Perazella MA. Drug-induced nephropathy: an update. Expert Opin Drug Saf. 2005;4(4):689–706.
4. Schnedler N, Burckhardt G, Burckhardt BC. Glyoxylate is a substrate of the sulfate-oxalate exchanger, sat-1, and increases its expression in HepG2 cells. J Hepatol. 2011 Mar;54(3):513-20.
5. Starr TB, Gibson JE. The Mechanistic Toxicology of Formaldehyde and Its Implications for Quantitative Risk-Estimation. Annu Rev Pharmacol. 1985;25:745-67.
6. Dong S, Dasgupta PK. Solubility of Gaseous Formaldehyde in Liquid Water and Generation of Trace Standard Gaseous Formaldehyde. Environ Sci Technol. 1986 Jun;20(6):637-40.
7. Board on environmental studies and toxicology. Report highlights. Review of the Formaldehyde Assessment in the National Toxicology Program 12th Report on Carcinogens. August 2014. Retrieved from: https://www.nap.edu/resource/18948/formaldehyde-report-highlights-Final2.pdf; and Board on environmental studies and toxicology. Report highlights. Review of the Formaldehyde Assessment in the National Toxicology Program 12th Report on Carcinogens. August 2014. Retrieved from: https://www.nap.edu/catalog/18948/review-of-the-formaldehyde-assessment-in-thenational-toxicology-program-12th-report-on-carcinogens. Both accessed on18.10.20
8. Pierce JS, Abelmann A, Spicer LJ, Adams RE, Glynn ME, Neier K, et al. Characterization of Formaldehyde Exposure Resulting from the Use of Four Professional Hair Straightening Products. J Occup Environ Hyg. 2011;8(11):686-99.
9. Monakhova YB, Kuballa T, Mildau G, Kratz E, Keck-Wilhelm A, Tschiersch C, et al. Formaldehyde in hair straightening products: Rapid 1H NMR determination and risk assessment. Int J Cosmetic Sci. 2013 Apr;35(2):201-6.
10. Aglan MA, Mansour GN. Hair straightening products and the risk of occupational formaldehyde exposure in hairstylists. Drug Chem Toxicol. 2020 Sep 2;43(5):488-95.
11. Peteffi GP, Antunes MV, Carrer C, Valandro ET, Santos S, Glaeser J, et al. Environmental and biological monitoring of occupational formaldehyde exposure resulting from the use of products for hair straightening. Environ Sci Pollut R. 2016 Jan;23(1):908-17.
12. Boj JR, Marco I, Cortés O, Canalda C. The acute nephrotoxicity of systemically administered formaldehyde in rats. Eur J Paediatr Dent. 2003;4(1):16-20.
13. Inker LA, Astor BC, Fox CH, Isakova T, Lash JP, Peralta CA, et al. KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD. Am J Kidney Dis. 2014 May;63(5):713-35.
14. Ahmed HM, El-Attat SH, Ismail W. Acute Kidney Injury Following Usage of Formaldehyde-Free Hair Straightening Products. Iran J Kidney Dis. 2019 Mar;13(2):129-31.
15. Mitler A, Houri S, Shriber L, Dalal I, Kaidar-Ronat M. Recent use of formaldehyde-'free' hair straightening product and severe acute kidney injury. Clin Kidney J. 2021 May;14(5):1469-71.
16. Anderson SE, Ham JE, Munson AE. Irritancy and sensitization potential of glyoxylic acid. J Immunotoxicol. 2008 Apr-Jun;5(2):93-8.
17. Boga C, Taddei P, Micheletti G, Ascari F, Ballarin B, Morigi M, et al. Formaldehyde replacement with glyoxylic acid in semipermanent hair

straightening: a new and multidisciplinary investigation. Int J Cosmetic Sci. 2014 Oct;36(5):459-70.