Recent use of formaldehyde "free" hair straightening product and severe acute kidney injury

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ABSTRACT

Formaldehyde is present in hair straightening products even when labeled as formaldehyde-free. Inhaled absorption of formaldehyde causes renal tubular cytotoxicity. We report a teenager who developed severe acute kidney injury requiring renal replacement therapy shortly after exposure to a formaldehyde "free" hair straightening product. Kidney biopsy showed acute tubular necrosis and images compatible with microcalcifications. Kidney function improved while on continuous venous-venous hemodialysis.

Keywords: acute tubular necrosis, Formaldehyde, haemodiafiltration, hair straightening, renal failure

BACKGROUND

Formaldehyde is a colorless aldehyde that is an essential ingredient in hair straightening products (1). Despite official regulations, the use of formaldehyde containing hair straightening products has become a popular practice among adult and pediatric populations. Analysis of hair straightening products revealed presence of formaldehyde in 8% of them despite being labeled FA free (1,2).

Formaldehyde is absorbed through the skin, eyes, and inhalation, and eliminated through urine (6). After a hair smoothing procedure, high air formaldehyde levels are found in beauty salons (3), leading to its presence in epithelial buccal cells, peripheral blood lymphocytes, and urine specimens of hairstylist workers (2,4,5). Elevated formaldehyde enhances the levels of free radicals, oxidative stress, and cytotoxic effect in acute toxic tubular necrosis (ATN) (7,8,9).

Acute kidney injury (AKI) presents as an abrupt decrease in kidney function, defined as an increase in serum creatinine (Scr) ≥ 0.3 mg/dL within 48 hours, an increase in Scr ≥ 1.5 times baseline level, or a urine volume production ≤ 0.5 ml/kg/h for 6 hours or ≤ 0.3 ml/kg/h for 24 hours (10).

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CASE REPORT

A 13-year-old previously healthy female arrived at the pediatric emergency department with abdominal pain, nausea, persistent vomiting, and oliguria. Her symptoms began three hours after applying a commercial hair straightening product (brand cannot be disclosed because of legal issues) advertised as formaldehyde free, in a private home beauty salon. On physical examination, the patient was pale, her vital signs revealed tachycardia (109 bpm), hypertension 160/85 mmHg, no fever, respiratory distress, or skin eruption. There was moderate dehydration and mild abdominal tenderness.

Laboratory investigations revealed metabolic acidosis with pH 7.31, HCO$_3$ - 20 mmol/L, and BE -5 mmol/L, and renal failure SCr 3.56 mg/dL and urea 107 mg/dL. Sodium, potassium, albumin, calcium, and hemoglobin were within the normal range (134.9 mmol/L, 3.91 mmol/L, 4.35 g/dL, 9.6 mg/dL, and 13.2 g/dL respectively). In the first 12 hours' urinary catheter output was 0.3 ml/kg/h, and a calculated FENa of 2.47%. Urine-analysis demonstrated hematuria without proteinuria, and a negative urine toxicology screen (for amphetamines, barbiturates, benzodiazepines and opiates). 24-hour urine collection revealed 327 mg protein and negative urine albumin, consistent with tubular proteinuria. Ultrasound revealed 15 cm edematous renal parenchyma. Levels of IgA, and complement C3, and C4 were normal. Serology for CMV and EBV, ASLO, Hepatitis C, ANCA, and anti-GBM was non-contributory.

Sixteen hours after arrival, renal replacement therapy by continuous venous-venous hemodialysis (CVVHD) was initiated. Within the first 31 hours of CVVHD, rapid GFR resolution was observed in three parameters: SCr declined from 3.14 mg/dL to 1.72 mg/dL (50.5%), while the level of urea decreased from 92.8 mg/dL to 52 mg/dL (56%), and urine output increased from 0.3 ml/kg/h to 1 ml/kg/h (330%).

On the 5th hospitalization day a renal core biopsy (Figure 1A-D) demonstrated 12 intact glomeruli with acute tubular necrosis mainly involving the proximal tubules with sparse nuclei and desquamation of cells into the lumen. Micro calcifications were incorporated within the tubular epithelium. Immunofluorescence analysis was negative, Masson-trichrome showed no fibrosis, and silver stain showed intact membranes.

When after 4 consecutive days CVVHD was terminated, urine output was 0.7 ml/kg/h, Urea 42 mg/dL and SCr 1.3 mg/dL. In a week, blood pressure decreased to 120/62 mmHg and urine production normalized. Prolonged tubular hyperphosphaturia (FEP 11.1%) and hypophosphatemia (range 1.6-3.5 mg/dL) remained for 3 months without glucosuria, hyperuricosuria or acidosis. At 6 months follow-up, all clinical and laboratory parameters had normalized (SCr, urea, sodium, potassium and phosphate 0.5 mg/dL, 31 mg/dL, 140 mmol/L, 4.3 mmol/L and 4.5 mg/dL respectively).

DISCUSSION

To our knowledge, this is the second report of AKI following hair straightening product exposure. The present case of severe acute tubular necrosis and calcifications requiring dialysis is similar to the single earlier publication of Heba Mostafa Ahmed et al(10).

The commercial hair straightening product is advertised as formaldehyde "free" and licensed in Israel only for hair lotion purposes and not-licensed for hair straightening procedures. A hypothesis is that the heating process during the straightening procedure may have changed the cream chemical structure and evaporated formaldehyde. When the case was reported to the Israeli health office, it was emphasized that heating the product is not approved
for this hair cream. The lack of skin irritation supports the assumption of inhaled formaldehyde absorption rather than contact exposure.

CVVHD was associated with a rapid reduction in creatinine and urea within the first 24 hours, which we consider disproportional to the dialysis extent, faster than the usual ATN spontaneous resolution, and was associated to an increase in urine output. We hypothesize that CVVHD may have contributed to clear toxins, potentially an aldehyde material. Previous reports suggest that both CVVHD and intermittent hemodialysis are suitable for extracorporeal rapid toxic ingredient elimination to prevent renal tubular damage. We initiated early CVVHD, since our pediatric ICU staff is more experienced with this method.

Regardless of official recommendations, inappropriate use of homemade hair creams, has become popular practice for "progressive straightening" among adult and pediatric population. While many individuals perform the procedure uneventfully, others, as the current case, present severe toxicity, potentially implying different individual sensitivity. We assume that younger age, lower body mass and unique pharmacokinetics can explain the difference. The coexistence with other nephrotoxic products cannot be definitely excluded.

Further information of pediatric and adult cases, with product ingredient analysis and patient's urine and blood samples, searching for formaldehyde derivatives, should be performed to evaluate whether hair straightening session and AKI are associated. Adult and pediatric nephrologists should be suspicious and alert to the potential tubular nephrotoxicity of hair straightening products.

In conclusion, we demonstrate a case of severe-dialysis dependent kidney damage after exposure to formaldehyde "free" hair straightening products, whose heating process is suspected to may have led to chemical composition changes and evaporation of formaldehyde.

CONFLICT OF INTEREST STATEMENT
None declared.

PATIENT CONSENT
Informed consent was obtained from the patient’s family to publish this case.
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Kidney biopsy. A, B: H&E staining; C, D: PAS staining. Note intact glomeruli (i) with acute tubular necrosis mainly involving proximal tubules with sparse nuclei (ii) and desquamation of cells into the lumen (iii). Microcalcifications were incorporated within the tubular epithelium (iii).

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