



EXCEPTIONAL CASE

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, hemodiafiltration, hair straightening, renal failure

BACKGROUND

Formaldehyde is a colorless aldehyde that is a common ingredient in hair straightening products. Despite official regulations, the use of formaldehyde-containing hair straightening products has become a popular practice among adult and pediatric populations. An analysis of hair straightening products revealed the presence of formaldehyde in 8% of them despite being labeled formaldehyde-free [1].

Formaldehyde is absorbed through the skin, eyes and inhalation and eliminated through urine. After a hair straightening procedure, high air formaldehyde levels are found in beauty salons [2], leading to its presence in epithelial buccal cells, peripheral blood lymphocytes and urine specimens of hairstylist workers [1, 3]. Elevated formaldehyde enhances the levels of free radicals, oxidative stress and the cytotoxic effect in acute toxic tubular necrosis (ATN) [4].

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 h, an increase in SCr ≥ 1.5 times the

baseline level or a urine volume production ≤ 0.5 mL/kg/h for 6 h or ≤ 0.3 mL/kg/h for 24 h [5].

CASE REPORT

A previously healthy 13-year-old female arrived at the pediatric emergency department with abdominal pain, nausea, persistent vomiting and oliguria. Her symptoms began 3 h after applying a commercial hair straightening product (brand not disclosed due to legal reasons), advertised as formaldehyde-free, in a private home beauty salon. On physical examination, the patient was pale, her vital signs revealed tachycardia (109 bpm) and hypertension 160/85 mmHg; she had 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 as well as renal failure with SCr 3.56 mg/dL and urea 107 mg/dL. Sodium, potassium, albumin, calcium and hemoglobin were within the normal range

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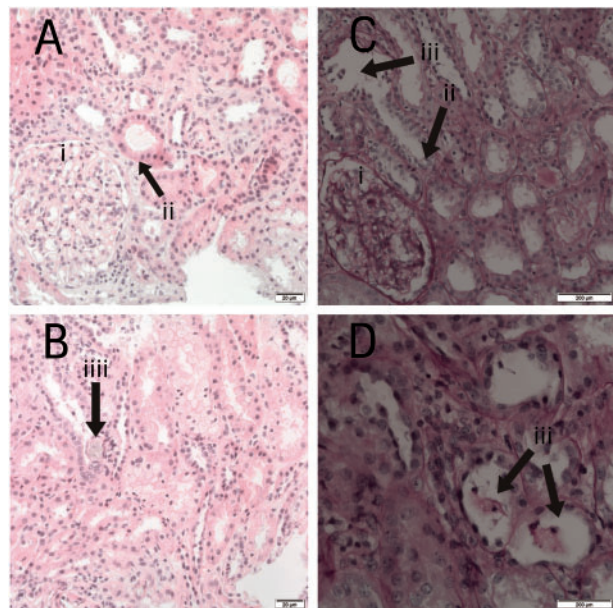


FIGURE 1: Kidney biopsy. (A and B) Hematoxylin and eosin staining; (C and D) periodic acid-Schiff staining. Note intact glomeruli (i) with acute tubular necrosis mainly involving the proximal tubules with sparse nuclei (ii) and desquamation of cells into the lumen (iii). Microcalcifications were incorporated within the tubular epithelium (iii).

(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 h, urinary catheter output was 0.3 mL/kg/h with a calculated fractional excretion of sodium of 2.47%. Urinalysis demonstrated hematuria without proteinuria and a negative urine toxicology screen (for amphetamines, barbiturates, benzodiazepines and opiates). The 24-h urine collection revealed 327 mg of protein and negative urine albumin, consistent with tubular proteinuria. Ultrasound revealed a 15-cm edematous renal parenchyma. Levels of immunoglobulin A and complement C3 and C4 were normal. Serology for cytomegalovirus and Epstein-Barr virus, anti-streptolysin O, hepatitis C, anti-neutrophil cytoplasmic antibodies and anti-glomerular basement membrane was noncontributory.

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

On the fifth 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. Microcalcifications were incorporated within the tubular epithelium. Immunofluorescence analysis was negative, Masson's trichrome showed no fibrosis and silver stain showed intact membranes.

After 4 consecutive days, CVVHD was terminated, urine output was 0.7 mL/kg/h, urea was 42 mg/dL and SCr was 1.3 mg/dL. In a week, blood pressure decreased to 120/62 mmHg and urine production normalized. Prolonged tubular hyperphosphaturia (fractional excretion of phosphate 11.1%) and hypophosphatemia (range 1.6–3.5 mg/dL) remained for 3 months without glucosuria, hyperuricosuria or acidosis. At the 6-month 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 Ahmed et al. [5].

The commercial hair straightening product is advertised as formaldehyde-'free' and licensed in Israel only for hair lotion purposes, not 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 Ministry of Health, it was emphasized that heating 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 and was associated with an increase in urine output within the first 24 h. We consider this to be disproportional to the dialysis extent and faster than the usual ATN spontaneous resolution. We hypothesize that CVVHD may have contributed to the clearing of 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 intensive care unit staff is more experienced with this method.

Regardless of official recommendations, inappropriate use of hair creams as homemade straightening products, has become popular practice for 'progressive straightening' among both the adult and pediatric populations. While many individuals perform the procedure uneventfully, others, as in 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 the patient's urine and blood samples, searching for formaldehyde derivatives, should be performed to evaluate whether a 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. It is suspected that the heating process with this product may have led to chemical composition changes and evaporation of formaldehyde.

PATIENT CONSENT

Informed consent was obtained from the patient's family to publish this case.

CONFLICT OF INTEREST STATEMENT

None declared.

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