

## Case Report



# Severe chemical burns related to dermal exposure to herbicide containing glyphosate and glufosinate with surfactant in Korea

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### Competing interests

The authors declare that they have no competing interest.

### Authors contributions

Conceptualization: Roh S; Data curation: Lim N; Formal analysis: Shin J; Funding acquisition: Roh S; Investigation: Roh S; Methodology: Shin J; Project administration: Roh S, Lim

## ABSTRACT

**Background:** Glyphosate and glufosinate use widely used as herbicide ingredients. There have been several reported cases of chemical burns caused by dermal exposure to glyphosate-containing herbicide, and patients in these cases were discharged without fatal complications. There were no cases of severe symptoms due to non-oral exposure of glufosinate-containing herbicides. Here, we report a case of fatality accompanied with severe chemical burns in an 81-year-old man who did not wash his skin for more than 48 hours after dermal exposure to herbicide containing glyphosate and glufosinate with surfactant (HGlyGluS).

**Case presentation:** An 81-year-old male with no underlying disease was admitted to the emergency department (ED). He had sprayed HGlyGluS with a manual knapsack sprayer 3 days ago and had not wash away the herbicide. On arrival, he was drowsy and had multiple severe corrosive skin lesions. Skin necrosis (10 × 15 cm) on the right shoulder and skin lesions with subcutaneous fat exposure (15 × 20 cm) on the right thigh were observed. Although he was treated including continuous renal replacement therapy, antibiotic apply, debridement operations, and so on, he was unable to recover and expired.

**Conclusions:** We suggest that prolonged dermal exposure to HGlyGluS induces fatality. Further studies including prolonged dermal exposure and ingredients of surfactants should be carried out. Also, it is necessary to educate farmers that it is very important to wash immediately after dermal exposure to pesticide.

**Keywords:** Glyphosate; Glufosinate; Herbicide; Dermal exposure; Chemical burns; Farmer

## BACKGROUND

Glyphosate and glufosinate use widely used as herbicide ingredients [1-3]. There have been several reported cases of chemical burns caused by dermal exposure to glyphosate-containing herbicide, and patients in these cases were discharged without fatal complications [4-6]. There were no cases of severe symptoms due to non-oral exposure of glufosinate-containing herbicides [7]. Symptoms of severe acute poisoning with herbicides containing glufosinate-ammonium occurred when taken orally [7,8].

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As far as we know, a fatal chemical burn case related to dermal exposure to herbicide containing glyphosate and glufosinate with surfactant (HGlyGluS) has not been reported yet. We present a case of severe chemical burns in connection with the patient not washing his skin for more than 48 hours after dermal exposure to HGlyGluS.

## CASE PRESENTATION

An 81-year-old male with no underlying disease was admitted to the emergency department (ED). He reported that he had sprayed herbicide with a manual backpack sprayer 3 days earlier. During the procedure, herbicide leaked from the sprayer and flowed down to right side of his back and right hip. The herbicide was composed of 40% glyphosate-isopropylamine, 4% glufosinate-ammonium and surfactant; however, the ingredients and concentrations of the surfactant is kept confidential by the manufacturer.

The patient did not wash his body after exposure, and three days later, severe skin corrosions occurred in the right shoulder, right flank, and right thigh. Due to associated severe burns and anuria, he visited a local hospital where a blood test was performed, and the result is shown in **Table 1**. Rhabdomyolysis was diagnosed through more than 10-fold increase in creatinine phosphokinase (CPK), less than 5% of CPK/creatinine kinase MB, elevated aspartate transaminase (AST), alanine aminotransferase (ALT), and lactate dehydrogenase. Increases in creatinine (Cr) and K<sup>+</sup> indicated impaired renal function, and blood urea nitrogen/Cr beyond 20 indicated pre-renal damage.

He was immediately transferred to the ED from the local hospital. On arrival, he was drowsy and had multiple severe corrosive skin lesions because continuous renal replacement therapy (CRRT) and treatment for skin necrosis was required. Skin necrosis (10 × 15 cm) on the right shoulder and skin lesions with subcutaneous fat exposure (15 × 20 cm) on the right thigh were observed. At that time, necrosis of his right thigh had progressed to the great trochanter of the femur, partially in the cephalic direction, and to the tendon fascia lata in the caudal direction. Parts of the latissimus dorsi and scapularis muscles were damaged on the right back, and the injury had spread to the axilla cavity in which the axilla artery and brachial plexus are present (**Fig. 1**). Low-density regions and fractures of the right femoral head in abdominal computed tomography (CT) images, which bone necrosis was assumed to have redounded (**Fig. 2**). A chest X-ray was taken at the time of the ED visit, and no pathological

**Table 1.** Blood test findings conducted at the local hospital at the time of visit

Variable	Value	Reference
AST	345 U/L	1–34 U/L
ALT	347 U/L	10–49 U/L
LDH	3,648 U/L	208–478 U/L
CPK	16,229 U/L	32–294 U/L
CK-MB	125 U/L	0–15 U/L
CK-MB/CPK	0.77%	-
Cr	6.54 mg/dL	0.7–1.3 mg/dL
BUN	152.2 mg/dL	9.0–23.0 mg/dL
BUN/Cr	23.27	-
Potassium (K <sup>+</sup> )	6.0 mEq/L	3.5–5.5 mEq/L
CRP	32.96 mg/dL	0–0.99 mg/dL

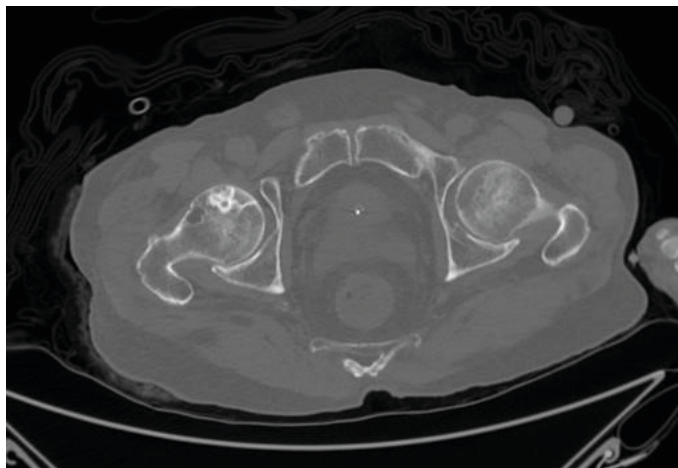
AST: aspartate transaminase; ALT: alanine aminotransferase; LDH: lactate dehydrogenase; CPK: creatinine phosphokinase; CK-MB: creatine kinase MB; Cr: creatinine; BUN: blood urea nitrogen; CRP: C-reactive protein.



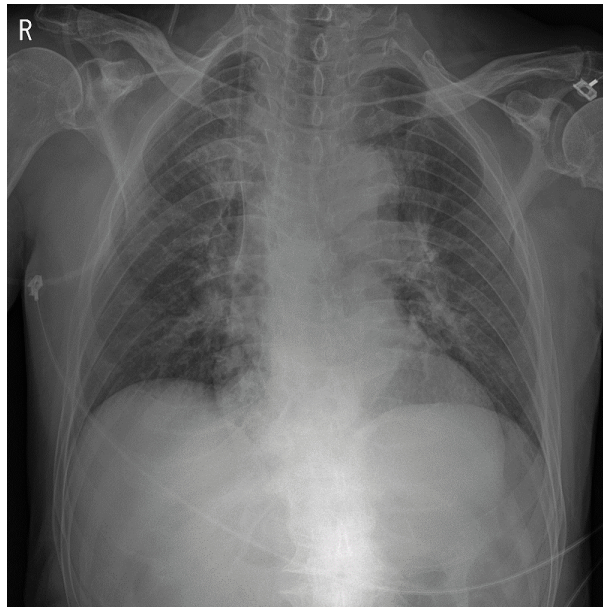
**Fig. 1.** Before the debridement operations, chemical burn wounds on the right side in the left lateral position.

findings were observed (**Fig. 3**). “Calcified granuloma in left lower lobe” was the only finding in non-contrast chest CT.

The patient was moved from the ED to the intensive care unit. Wound dressing, antibiotic therapy, and CRRT were performed. The 1st debridement operation was performed on the 13th day from admission. Due to the risk of brachial plexus injury, cooperation with orthopedic surgeons was requested. On the 19th day of hospitalization, the 2nd debridement operation was performed by plastic surgeons and orthopedic surgeons. At the 20th day, his systolic blood

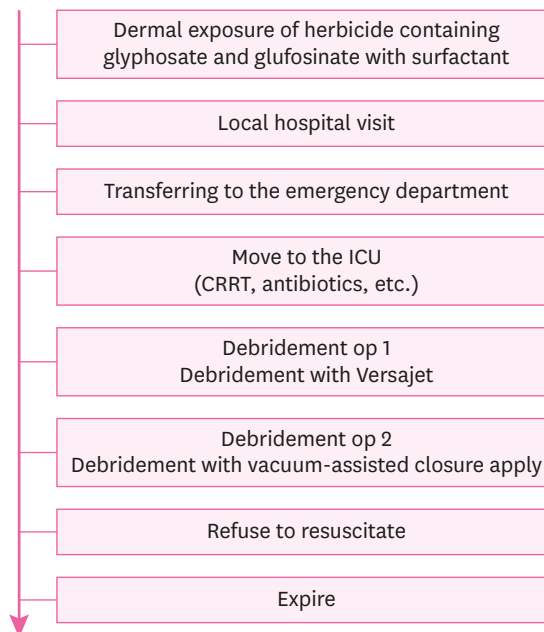


**Fig. 2.** Osteonecrosis of the right femoral head. Abdominal computed tomography axial view (window width: 2501, window level: 250).



**Fig. 3.** A chest X-ray. Anteroposterior view.

pressure was determined to be 60 mmHg, lactate 7.0 mmol/L, white blood cell count 16,570/ $\mu$ L, and his body temperature was 38.6°C. His family was contacted for approval for intubation and cardio-pulmonary resuscitation, but they refused any further treatment. The patient expired on the 22nd day of hospitalization (**Fig. 4**). For this study, we obtained approval from the Institutional Review Board of Dankook University Hospital (IRB No. 2020-02-025).



**Fig. 4.** The flow chart from dermal exposure of herbicide to death. ICU: intensive care unit; CRRT: continuous renal replacement therapy; op: operation.

## DISCUSSION AND CONCLUSION

A report of serious chemical burns associated with dermal exposure to HGlyGluS has not been found yet. We report the first case of fatality with severe chemical burns in a farmer who did not wash for more than 48 hours after dermal exposure to HGlyGluS.

Since this case was confirmed after the patient died, there is a limitation that it is not possible to identify the herbicide product used directly on the patient. However, according to the record at the ED visit, we were able to confirm the fact that he had used the herbicide containing glyphosate and glufosinate together. According to the list of herbicides used in Korea provided by the National Academy of Agricultural Sciences, there are 65 glyphosate-containing herbicides and 45 glufosinate-containing herbicides. Two herbicide products containing glyphosate and glufosinate together were identified. The components of both products were identical with 40% glyphosate-isopropylamine, 4% glufosinate-ammonium, and surfactants [9].

Previous studies have shown that herbicides with surfactants may be more toxic than those without, but ingredients and concentrations of the surfactant used in commercial herbicides are regarded as trade secrets and may vary depending on the manufacturer [1,10-12]. Most of the surfactants in herbicides are complexes of more than two ingredients [11]. Polyethoxylated tallow amine (TN-20) and polyoxyethylene lauryl amine ether (LN-10) are commonly found in glyphosate-contained herbicides in Korea [12]. Severe cellular toxicity of TN-20 and LN-10 has been confirmed in an *in vitro* study [11,12]. Thus, it was unable to identify the ingredient of the surfactant sprayed in this case. Providing accurate and more detailed information about surfactant is essential, especially for farmers and medical staffs.

Glufosinate have low toxicity to rabbits when applied to the skin [13,14]. Also, the skin toxicity of glyphosate is considered low [1]. However, there have been several reported cases of chemical burns caused by dermal exposure to glyphosate-containing herbicides [4-6]. In these cases, the patients developed local swelling, bullae and exuding wounds. The skin lesions healed in several weeks. Although neurological impairment followed in one of the cases, impact was limited to osteopenia of carpal bones and contracture of hand muscles, which resulted in deformation. In addition, a case of intramuscular injection of glyphosate-containing herbicides is reported. After injection, local inflammation and rhabdomyolysis followed near the puncture sites [15].

Herbicide toxicity is highly influenced by duration, frequency and intensity of exposure. Another variable that may affect toxicity is susceptibility of target organism, which is influenced by age, gender, state of health, and genetic variation [16]. Moreover, studies have shown that the skin penetration of glyphosate about 5 times higher in damaged skin [17]. While presence of wound on the skin is unknown, considering farmer's age of 81, his aged agricultural skin has sufficient probability of sustaining higher chemical permeability than the skin of a healthy person.

Systemic effect of glyphosate-containing herbicide poisoning via oral may induce kidney injury and pulmonary diseases such as pulmonary congestion or pneumonia [18]. In case of skin absorption of herbicide insomuch as to induce systemic toxic effect, defects should have been noticed on lung as well as kidney. However, in this case, no pathological findings were seen in chest CT and chest X-ray views. Therefore, the possibility of direct multi-organ damages, such as kidney, lung, and heart, caused by HGlyGluS skin absorption seems relatively low.



Burn-related acute kidney injury (AKI) is usually classified as either early (post-burn day 0–3) or late (post-burn day 4–14). Early AKI is observed in the early resuscitation phase after severe burns and is thought to be due to rhabdomyolysis, hypovolemia, increased inflammatory mediators, release of denatured proteins, and cardiac dysfunction. AKI is one of the main complications of burns and has a high mortality rate [19,20]. Therefore, the AKI in this case appears to be a serious complication of burns from skin exposure to HGlyGluS. This shows the possibility that AKI may be triggered in a different path than the case of poisoning. Therefore, the AKI in this case appears to be a complication of burns from dermal exposure to HGlyGluS.

In conclusion, we report the first case of fatality with severe chemical burns in a farmer who did not wash for more than 48 hours after dermal exposure to HGlyGluS. We suggest that prolonged dermal exposure to HGlyGluS induces fatality. There is a need for future study on the health effects of herbicides on long-term skin exposure. Providing more detailed information about pesticide including surfactants is essential, especially for farmers and medical staffs. Also, it is necessary to educate farmers that it is very important to wash immediately after dermal exposure to pesticide.

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