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Contrast-Enhanced Computed Tomography in Intensive Care Unit Patients with Acute Clinical Deterioration: Impact of Hyperattenuating Adrenal Glands

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Abstract

Purpose: The study sought to assess the frequency and prognostic value of hyperattenuating adrenal glands on contrast-enhanced computed tomography (CT) scans of surgical intensive care unit (ICU) patients with acute clinical deterioration.

Methods: Eighty-eight consecutive ICU patients (63.2 ± 14.5 years of age) were included in this retrospective analysis. All patients underwent biphasic contrast-enhanced CT due to an acute clinical deterioration. Hyperattenuation of the adrenal glands was assessed subjectively and objectively. Subjective presence or absence of hyperattenuating adrenal glands was assessed by 2 blinded radiologists (J.B. and R.S.L.) in consensus. Hounsfield units (HU) were measured in the adrenal glands and in the inferior vena cava. Objective hyperattenuation was defined as HU (adrenal glands) > HU (inferior vena cava) with a 15-HU threshold. Death within 14 days following CT was set as endpoint and acquired from electronic patient data.

Results: Thirty-eight patients (43.2%, Group A_{subj}) exhibited hyperattenuation of the adrenal glands, whereas 50 patients (56.8%, Group B_{subj}) did not. Concerning the objective analysis, 31 patients (35.2%, Group A_{obj}) exhibited hyperdense adrenal glands, whereas 53 patients (64.8%, Group B_{obj}) did not. Overall 27 of 88 patients (30.6%) died within 14 days following the CT examination. Lethal outcome was significantly more frequent among patients in Group A_{subj} and A_{obj} (19 of 38 patients [50.0%] and 15 of 31 patients [48.4%]) as compared with patients in Group B_{subj} (8 of 50 patients [16.0%]) and Group B_{obj} (12 of 57 patients [21.1%]; $P < .05$). Subjective and objective analysis correlated significantly ($P < .05$).

Conclusions: Hyperattenuation of adrenal glands on contrast-enhanced CT of ICU patients with acute clinical deterioration is associated with a high mortality and might serve as a prognostic marker for patients' outcome.

Résumé

Objet : Cette étude visait à évaluer la fréquence et la valeur pronostique des glandes surrénales hyperatténuantes lors de TDM avec injection de produit de contraste chez les patients d'unités de soins intensifs chirurgicaux présentant une détérioration clinique sévère.

Méthodes : Quatre-vingt-huit patients consécutifs provenant d'unités de soins intensifs (63,2 ans, $\pm 14,5$ ans) ont été inclus dans cette analyse rétrospective. Tous les patients ont subi une TDM biphasique avec injection de produit de contraste en raison d'une détérioration clinique sévère de leur état. L'hyperatténuation des glandes surrénales a été évaluée subjectivement et objectivement. La présence ou l'absence subjective de glandes surrénales hyperatténuantes a été évaluée à l'aveugle par deux radiologistes (J.B. et R.S.L.), par consensus. Les unités Hounsfield (UH) ont été mesurées dans les glandes surrénales et dans la veine cave inférieure. L'hyperatténuation objective a été définie comme un nombre d'UH des glandes surrénales > au nombre d'UH de la veine cave inférieure, avec un seuil de 15 UH. Un décès dans les 14 jours suivant la TDM était défini comme indicateur de résultat. Cette information était tirée du dossier électronique du patient.

Résultats : Trente-huit patients (43,2 %, groupe A_{subj}) montraient une hyperatténuation des glandes surrénales, alors que 50 patients (56,8 %, groupe B_{subj}) n'en présentaient pas. Dans le cadre de l'analyse objective, on a trouvé des glandes surrénales hyperdenses chez 31 patients (35,2 %, groupe A_{obj}), alors que 53 patients (64,8 %, groupe B_{obj}) n'en avaient pas. Au total, 27 des 88 patients (30,6 %) sont décédés dans

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les 14 jours suivant la TDM. L'issue était beaucoup plus souvent fatale chez les patients des groupes A_{subj} et A_{obj} (19 des 38 patients [50,0 %] et 15 des 31 patients [48,4 %]) que chez les patients des groupes B_{subj} (8 des 50 patients [16,0 %]) et B_{obj} (12 des 57 patients [21,1 %]; $P < 0,05$). On note une forte corrélation entre les analyses subjective et objective ($P < 0,05$).

Conclusions : L'hyperatténuation des glandes surrénales dans les TDM avec injection de produit de contraste chez les patients des unités de soins intensifs présentant une détérioration clinique sévère est associée à un haut taux de mortalité et pourrait servir de marqueur pronostique de l'issue pour les patients.

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Key Words: Adrenal gland; Contrast-enhanced computed tomography; Hyperattenuation; Intensive care unit

The adrenal glands are located in the retroperitoneum and consist of the cortex and medulla. The adrenal medulla is part of the sympathetic nervous system and produces catecholamines [1].

In case of hypotension, caused for example by an acute trauma or severe illness, these hormones are secreted as a reflex to nervous stimulation to counteract reduced blood flow to the brain, heart, and muscles [2]. Hence, marked contrast enhancement of the adrenal glands has been described as part of the hypoperfusion complex [3,4].

Normally the density of the adrenal glands in contrast-enhanced computed tomography (CT) equals the density of other solid abdominal organs such as liver or spleen and is decreased compared to the inferior vena cava (IVC). Density measurements of the adrenal glands are often performed to evaluate adrenal masses [5], but only a few studies have focused on adrenal enhancement in critically ill patients [4,6]. In a recent study, Schek et al [6] demonstrated an association of hyperattenuating adrenal glands with a higher mortality in polytraumatized patients, indicating that hyperattenuation of the adrenal glands might be considered as a predictor of poor clinical outcome. According to our experience, contrast-enhanced CT frequently reveals hyperattenuating adrenal glands in intensive care unit (ICU) patients.

The purpose of the present study was to evaluate the prognostic value of hyperattenuating adrenal glands in ICU patients undergoing CT examinations due to severe clinical deterioration.

Material and Methods

Patients and Data Collection

This retrospective study was approved by the local ethics committee. Eighty-eight consecutive ICU patients (60 men, 28 women, 63.2 ± 14.5 years of age) who underwent contrast-enhanced abdominal CT in arterial and venous phase between January 2010 and May 2011 were included in this analysis. There were no exclusion criteria. Reasons for admittance to surgical ICU are shown in Table 1. CT examinations were performed for the evaluation of acute complications like bleeding, acute respiratory distress syndrome or acute deterioration in course of an infection (Table 1). Twelve patients did not undergo surgery prior to ICU admission and were admitted due to terminal cancer stage ($n = 3$), severe

intoxication ($n = 1$), trauma ($n = 2$), planned heart transplantation ($n = 1$), or septic shock ($n = 5$).

CT Protocol

All CT examinations were performed on a multidetector CT scanner (Emotion 6, Siemens AG Healthcare, Forchheim, Germany). Image acquisition parameters were as follows: tube voltage: 110 kV, pitch: 1, reference tube current time product: 170 mAs. Contrast medium (100 mL; Accupaque 300, GE Healthcare, Munich, Germany) was injected using a power injector (Nemoto Dual Shot, MMS Medicor Medical Supplies GmbH, Kerpen, Germany). Contrast medium injection was routinely performed with 3–4 mL/s, depending on the venous access. Contrast medium injection was followed by a saline flush (40 mL) in all patients. All CT examinations were performed both in the arterial and venous phase. The arterial phase was started using bolus trigger technique with a threshold of 100 Hounsfield units (HU) in the descending aorta. The venous phase was performed 70 seconds after the arterial phase. All examinations were performed at 110 kV and automated tube current modulation was activated in all scans (CAREDose 4D, Siemens AG, Healthcare Section).

Subjective Image Analysis

CT examinations were retrospectively reviewed by 2 radiologists (J.B. and R.S.L.) with 2–8 years of experience in interpreting abdominal CT, who were blinded to patients' clinical data. Subjective evaluation was performed on a PACS workstation (Sectra Medical Systems GmbH, Linköping, Sweden). Attenuation of the adrenal glands was compared to the attenuation of the IVC. In all cases, the arterial and venous phase images were evaluated. Image analysis was performed on 2.5 mm and 5 mm slices and window modulation was to the discretion of the readers. Both readers reviewed at all images together and came to a decision in consensus. Patients were divided into 2 groups (Group A_{subj}: hyperattenuation of the adrenal glands; Group B_{subj}: no hyperattenuation of the adrenal glands).

Objective Image Analysis

For quantitative analysis, HU were determined in the confluence of both adrenal limbs and in the IVC using region-of-interest measurements in the 2.5 mm axial CT

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