

Whole Body CT for a Patient with Sepsis

Y. Yanagawa, K. Aihara, S. Watanabe, M. Takemoto, T. Naito, T. Iba, and H. Tanaka

Abstract—This study retrospectively investigated the significance of whole body CT (WCT) for patients with sepsis. A medical chart review was retrospectively performed for all patients with systemic inflammatory response syndrome that were treated initially between April 2011 and March 2012. The subjects were divided into a WCT group that underwent WCT on arrival and a control group. Results of this study suggested that WCT for sepsis was useful for elderly patients whose chief complaint or physiological findings could not suggest the anatomical site of infection, to determine the infectious focus and indications/method for surgery, to diagnose the basic diseases associated with opportunistic infections and to evaluate complicated diseases.

Keywords—Sepsis, CT, outcome.

I. INTRODUCTION

THE Surviving Sepsis Campaign was developed to reduce mortality from sepsis via a multi-point strategy [1]. This campaign recommended obtaining appropriate cultures before starting antibiotics and to begin intravenous broad-spectrum antibiotics as early as possible, and always within the first hour of recognizing severe sepsis and septic shock. This campaign also reported that the specific anatomical site of infection should be established as rapidly as possible and within the first 6 hours of presentation. Formally evaluating patients for the focus of infection allows source control measures such as abscess drainage or tissue debridement. However, there are no concrete methods to find the specific anatomical site of infection.

Focal computed tomography (CT) allows for earlier identification of specific sites of infection than plain roentgenograms among febrile patients because of its high contrast resolution [2], [3]. Sepsis tends to occur in elderly patients that might have poor communication due to dementia or cerebrovascular injury [4]. In addition, altered consciousness induced by sepsis might make them unable to communicate, which results in difficulty in identifying the specific site of infection. Whole-body CT in early trauma care significantly increased the probability of survival in patients with polytrauma in comparison to non-whole-body CT, so that whole-body CT is recommended as a standard diagnostic method during the early resuscitation phase for patients with polytrauma [5].

Some medical institutes, including this department, in Japan, use whole body CT to detect the specific site of infection

without any evidence [6]-[8]. Therefore, this study retrospectively investigated the significance of whole body CT for patients with sepsis.

II. METHODS

This retrospective study protocol was approved by the review board of Juntendo University Hospital, and examinations were conducted according to the standards of good clinical practice and the Helsinki Declaration. Juntendo University Hospital is located in the middle of Tokyo, and has 1000 beds. The department of Emergency Medicine, Juntendo University is classified as a primary and secondary medical facility from the standpoint of emergency care. Primary emergency medical facilities receive patients that are not in serious condition—that can walk in for treatment and do not need hospitalization, such as patients with flu, diarrhea or simple contusions. Secondary medical facilities receive patients that cannot walk on their own and need hospitalization, but are not in critical condition, such as those with pneumonia, appendicitis or fractures. This hospital had four CT machines, and patients can be evaluated by CT at any time. Patients treated by emergency physicians are usually evaluated by 16-row multi-detector CT (Activion™ 16^R, Toshiba Medical Systems Cooperation, Tochigi, Japan).

A medical chart review was retrospectively performed for all patients with systemic inflammatory response syndrome (SIRS) that were treated initially by this department between April 2011 and March 2012. The criteria for SIRS are patients with least two of four factors: 1) body temperature less than 36°C or greater than 38°C, 2) Heart rate greater than 90 beats per minute, 3) tachypnea with greater than 20 breaths per minute, and 4) white blood cell count less than 4000 cells/mm³ or greater than 12,000 cells/mm³ or the presence of greater than 10% band forms neutrophils. The subjects were divided into a whole body CT group (WCT) that underwent whole body CT on arrival to detect the specific anatomical site of infection and a control group that did not undergo whole body CT. Whole body CT was defined as an examination from head to pelvis. The patients' age, sex ratio, physical data on arrival (systolic blood pressure, heart rate, respiratory rate and temperature), white blood cell count on arrival, chief complaint or physiological findings that suggested the anatomical site of infection, whole body CT to suggest the anatomical site of infection, need for surgical intervention, number of positive culture results, and the survival rate were all compared between the two groups. In addition, the study investigated whether useful clinical radiological information could be obtained sites apart from the main anatomical site of infection among the

Youichi Yanagawa, Koichiro Aihara, Shin Watanabe, Masaaki Takemoto, Toshiaki Iba, Hiroshi Tanaka, Toshio Naito are with the Juntendo University, 2-1-1 Hongo Bunkyo-ku, Tokyo, Japan (phone:81-3-3813-3111, fax: 81-3-3814-5431, e-mail:yyanaga@juntendo.ac.jp)

WCT group. The head/face, neck, chest, abdomen/pelvis and extremity were treated as different sites in this study.

The statistical analyses were performed using unpaired Student's *t*-tests and the χ^2 analysis. A *p* value < 0.05 was considered to indicate a statistically significant difference. All data are presented as the means \pm standard error.

III. RESULTS

One thousand two hundred twenty-five patients underwent their first medical examination by emergency physicians of Juntendo University Hospital, 109 of which had experienced a fever. Forty-five patients of those patients met the criteria of SIRS on arrival and were included as study subjects. There were 18 cases in the WCT group and 27 cases in the C group. Focal CT was performed in 15 cases in the control group, based on the patient's chief complaint or physiological findings.

The results of the analysis are shown in Table I and the clinical diagnosis is shown in Table II. There were no significant differences between the two groups in the sex ratio, physical data, white blood cell counts, ratio of successful demonstration of the anatomical site of infection among the patients that underwent CT and the survival ratio. However, the average age in the WCT group was significantly higher than in the C group. There were 7/17 cases (38.8%) whose chief complaint or physiological findings could suggest the anatomical site of infection in the WCT group, however, the chief complaint or physiological findings did suggest the anatomical site of infection in 25/27 cases (92.5%) in the C group and these difference were statistically significant (*p*=0.0002). The content and number of chief complaints in subjects that failed to demonstrate the site of infection in the WCT group were general fatigue in 11, unconsciousness in 4, vomiting in 3, and feeling of heat in 3. The ratio of patients indicated for surgical intervention and with positive results of culture in the WCT group was significantly higher than that in the C group (44.4% vs. 3.7%; *p*=0.01, 72.2% vs. 34.6%; *p*=0.03 respectively).

Six subjects of the subjects that were indicated for surgical intervention in the WCT group needed abscess drainage or necrotomy of an infectious organ [9]. One of the six cases had a bilateral psoas abscess and dementia requiring complete care. Her caretaker refused to allow surgical intervention and the patient died. One of the eight cases had a diagnosis of an abdominal aortic aneurysm and underwent resection and interposition of graft after pneumonia was cured. A multiple mass lesion was found in one of the eight cases and a biopsy of one of masses revealed IgG4 syndrome. This case underwent steroid treatment after pyelonephritis was cured.

The results of the investigation of whether useful clinical radiological information could be obtained other than the site of infection among the WCT group is shown in Table III. The clarification of concomitant aspiration and intestinal pneumonia was useful to grasp mechanism of hypoxia in subjects. The clarification of concomitant sinusitis or pyelonephritis was useful to interpret complaints such as facial

pain or back pain. The clarification of a concomitant abdominal aortic aneurysm resulted in aortic replacement after control of the infection. The identification of a concomitant periaortic, intrahepatic and lachrymal gland mass was useful to determine the site of a biopsy, obtain diagnosis of IgG4 syndrome and prescribe steroids after control of infection, and understand the cause of an opportunistic infection.

TABLE I
RESULTS OF THE ANALYSIS

Variable	WCT group	Control group	<i>p</i>
Age (years old)	72.1 \pm 3.2	48.6 \pm 4.1	<i>p</i> =0.0002
Sex (Male/Female)	(10/8)	(16/11)	n.s.
Systolic blood pressure (mmHg)	127.6 \pm 5.7	120.9 \pm 4.1	n.s.
Heart rate (/minute)	95.6 \pm 3.5	94.7 \pm 3.1	n.s.
Temperature (Celsius)	37.5 \pm 0.3	37.7 \pm 0.2	n.s.
Respiratory rate (/minute)	24.2 \pm 1.5	3.9 \pm 1.1	n.s.
White blood cell count (/ μ l)	10,776 \pm 1,562	11,665 \pm 689	n.s.
Suggestion of the anatomic site of infection by complaints or physiological findings(yes)	7 (38.8%)	25 (92.5%)	<i>p</i> =0.002
Suggestion of the anatomic site of infection by CT (yes)	16 (88.8%)	11/n=15 (73.3%)	n.s.
Indication for surgical intervention	8 (44.4%)	1 (3.7%)	<i>p</i> =0.01
Number of positive results of culture	13 (72.2%)	10 (34.6%)	<i>p</i> =0.03
Survival rate	17 (94.4%)	26 (100%)	n.s.

N.S.=not significant, WCT: whole body computed tomography

TABLE II
CLINICAL DIAGNOSIS AND SURGICAL INDICATIONS

Main clinical diagnosis	WCT group number	Surgical indication	Control group number	Surgical indication
Pyelonephritis	5	3	2	0
Pneumonia	4	Operation for AAA 1	5	0
Gastroenteritis	3	0	10	0
Pyothorax	1	1	0	0
Virus upper tract infection	1	0	6	0
Phlegmone	1	1	2	0
Retrotonsillar abscess	1	1	0	0
Psoas abscess	1	1	0	0
Tuberculosis	1	0	0	0
Appendicitis	0	0	1	1
Sinusitis	0	0	1	0

AAA=abdominal aortic aneurysm

TABLE III
ADDITIONAL CLINICAL USEFULNESS OF RADIOLOGICAL FINDINGS OF RESULTS OF WHOLE BODY CT AMONG WCT GROUP

Clinical diagnosis	Number	Clinical usefulness
Aspiration pneumonia	5	Cause of hypoxia
Sinusitis	2	Cause of upper air way symptom
Interstitial Pneumonia	1	Cause of hypoxia
Pyelonephritis	1	Cause of back pain
Ileus	1	Careful tube feeding
Abdominal aortic aneurysm	1	Elective operation
IgG4 syndrome	1	Cause of opportunistic infection

IV. DISCUSSION

This study suggested that whole body CT for sepsis was useful for aging people whose chief complaint or physiological findings could not suggest the site of infection, to determine the site of infection and the indications/methods of surgery, to diagnose basic diseases associated with opportunistic infections and to evaluate complicated diseases. This is because the CT has superior spatial resolution in comparison to x-ray or ultrasound.

Whole body CT suggested 88% of the sites of infection. However, it was difficult to determine the focal site of meningitis, catheter infection, endocarditis, bony or artificial infection, of liver abscess by plain CT without contrast medium. Eriguchi et al. reported that whole body CT failed to detect the specific infected site in a patient with Group A Streptococcus, resulting in the patient's death [7]. MRI, gallium scintigraphy and positron emission tomography-computed are superior to CT for detecting the specific infected site in some diseases [10]. However, these modalities are difficult to use at any time for a critical patient that requires life support, and CT can be used for such patients [10].

This study found no difference in the outcome between the two groups. However, the average age in the WCT group was older than that in the control group. The outcome of older patients with sepsis is poor in comparison to younger patients so that the outcome of the WCT group should have been worse than that of the control group [11]. In addition, one lethal case in the WCT group had a psoas abscess, diagnosed by whole body CT, and was not given a chance to survive because her caretaker refused to allow surgical drainage of the abscess. Therefore, whole body CT for sepsis may improve the outcome of elderly patients with sepsis that cannot indicate the infected site of their complaints, by allowing the early detection and intervention of the focal infected site.

The disadvantage of whole body CT is the risk of radiation-induced cancer [12]. The increase in CT use and in the CT-derived radiation dose in the population is occurring just as the understanding of the carcinogenic potential of low doses of x-ray radiation has improved substantially, particularly among children. All of the subjects in this study were over 19 years old. However, CT is a potential risk for radiation-induced cancer, and a suitable indication for septic patients should be clarified.

The limitations of this study are its small sample size and retrospective nature. One of several problems is the immediate interpretation of CT, which yields a lot of radiological information in the clinical emergency setting. The efficacy of whole body CT for septic patients that can suggest the location of the infected site is unclear. In addition, the indications for whole body CT in septic children, in the light of the radiation-induced cancer risk. Therefore, a further prospective study, including a larger number of subjects, is required to confirm the current findings by a comparison of patients with or without whole body CT examination for septic patients and to clarify the obvious indications.

V. CONCLUSION

Whole body CT for sepsis might be usefulness for elderly people whose chief complaint or physiological findings could not indicate the site of infection, to determine the infectious focus and the indications/methods of surgery, to diagnose the basic disease of an opportunistic infection and to evaluate complicated diseases. However, a further prospective study, including a larger number of subjects, is required to confirm these findings.

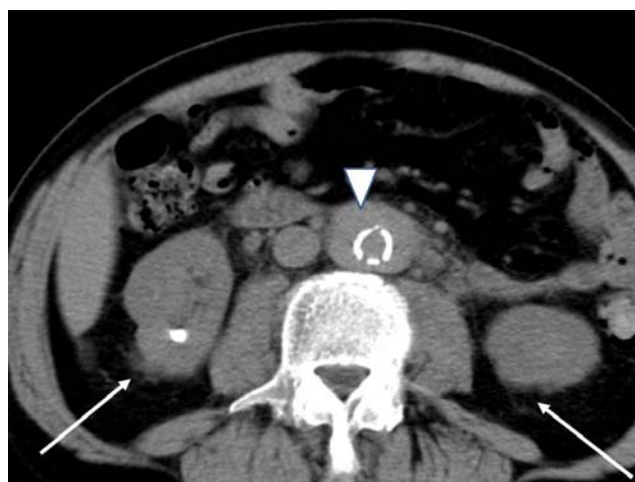


Fig. 1 Whole body CT on arrival

The whole body CT of a seventy-year-old male with general fatigue and vomiting revealed dirty fat sign around the kidney (arrow) suggesting pyelonephritis. A concomitant periaortic mass is also indicated (triangle). This case was diagnosed as IgG4 syndrome by the results of a biopsy.

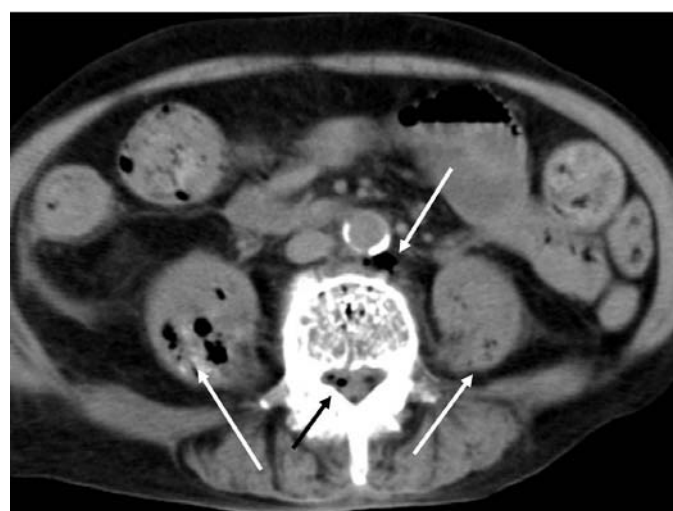


Fig. 2 Whole body CT on arrival

The whole body CT of a seventy-seven-year-old female with altered consciousness reveals abnormal gases in bilateral psoas muscle, anterior spine and intraspinal canal (arrow), suggesting psoas abscess. This is useful to grasp the site of the infection.

REFERENCES

- [1] R.P.Dellinger, M.M.Levy, J.M.Carlet, et al, "Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock," *Crit Care Med* vol.36, pp296-327, 2008.
- [2] C.P. Bleeker-Rovers, F.J.Vos, E.M.Kleijn, et al, "A prospective multicenter study on fever of unknown origin: the yield of a structured diagnostic protocol," *Medicine (Baltimore)*, vol.86,pp26-38, 2007.
- [3] J.Barkhausen, F.Stöblen, E.Dominguez-Fernandez, et al, "Impact of CT in patients with sepsis of unknown origin," *Acta Radiol* vol.40, pp552-5, 1999.
- [4] G. Kumar, N. Kumar, A Taneja, et al, "from the Milwaukee Initiative in Critical Care Outcomes Research (MICCOR) Group of Investigators. Nationwide trends of severe sepsis in the 21st century (2000-2007)," *Chest* vol.140, pp1223-31, 2011.
- [5] S.Huber-Wagner, R.Lefering, L.M.Qvick, et al; Working Group on Polytrauma of the German Trauma Society, "Effect of whole-body CT during trauma resuscitation on survival: a retrospective, multicentre study," *Lancet*, vol 373, pp1455-61,2009.
- [6] T.Nagai, C.Inoue, K.Tonouchi, et al,"Multiple Organ Failure Followed by Intrauterine Klebsiella Pneumoniae Infection Associated with Diabetes Mellitus," *Kitakanto Med J* vol.59, pp151-5, 2009. In Japanese
- [7] Y.Eriguchi, S.Ri, N.Fujimura,et al, "A case of invasive Group A *Streptococcus* infection," *Rinsho to Kenkyu* vol.89, pp111-3, 2012. In Japanese
- [8] T.Fujiwara, T.Nagai, K.Kaneko, et al, "Candida Glabrata Fungemia After Amputation of an Infected Diabetic Foot," *Kitakanto Med J* vol.60, pp259-63, 2010. In Japanese
- [9] Y.Yanagawa, Y.Hirano, N.Matsumoto, et al, "Emphysematous pyelonephritis induced by *Citrobacter freundii*," *J Emerg Trauma Shock* in press.
- [10] M.Gotthardt, C.P.Bleeker-Rovers, O.C.Boerman, et al, "Imaging of inflammation by PET, conventional scintigraphy, and other imaging techniques," *J Nucl Med* vol.51, pp1937-49, 2010.
- [11] S.M.Opal, T.D.Girard, E.W.Ely, , "The immunopathogenesis of sepsis in elderly patients," *Clin Infect Dis*. Vol.41 Suppl 7, ppS504-12, 2005.
- [12] D.J.Brenner, E.J.Hall, "Computed tomography: An increasing source of radiation exposure," *N Engl J Med* vol. 357, pp2277-84, 2007.