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Electroconvulsive Therapy Decreases Digital Skin Blood Flow under Propofol Anesthesia

Takeshi Tateda*, Koji Hara*, Kenji Yagi*, Naoya Maruyama*, Yuji Fukushima*, Osamu Tajiri*, Tadashi Aoki*

Abstract

The relationship between changes in hemodynamics and the digital skin blood flow (DBF) was investigated by laser Doppler flowmetry during electroconvulsive therapy (ECT) under propofol anesthesia. Under anesthesia with propofol and succinylcholine, ECT lasting for 5 sec was induced in 7 patients with depression. They were monitored by continuos ECG and pulse oxymetry, intermittent blood pressure, using an automatic blood pressure apparatus. The DBF of the first finger was also continuously measured with laser Doppler flowmetry. ECT caused a marked elevation in systolic and diastolic blood pressures and a significant reduction in the DBF. The DBF was restored within several minutes after ECT. There was a statistically significant linear correlation between the increase in systolic or diastolic blood pressure and the decrease in the DBF ($r=0.62$, $p<0.001$), but no linear correlation between the changes in heart rate and the DBF. It was concluded that those changes were due to a sympathetic response to ECT. Our results indicate that the DBF reflects sympathetic nervous activity during ECT under propofol anesthesia.

Key Words: Digital skin blood flow, Laser Doppler flowmetry, Propofol, Electroconvulsive therapy, Sympathetic nervous activity

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Electroconvulsive therapy (ECT) has recently been adopted for severe depressive disorders, which occur frequently in older patients[1,2]. ECT has been applied increasingly and more frequently to these aged patients with depression for several reasons. First, the elderly suffers from complications caused by pharmacotherapy more frequently than their younger counterparts. Second, sometimes depression is a serious disease and requires an urgent therapy. Geriatric psychiatric patients are also frequently present several other medical conditions, such as hypertension, cerebral vascular disease, and ischemic heart disease. Further, many of these medical condition, per se, in the elderly can be the cause of depression[3].

Several studies reported that depression is a significant risk factor for death after a myocardial infarction or cerebrovascular disease[4,5]. Because ECT causes exaggerated cardiovascular responses, such as a catecholamine storm, it sometimes leads to dangerous hemodynamic instability in susceptible patients[6]. Steiner, et al. described a case of heart failure and inferolateral subendocardial infarction that developed following ECT[7]. However, the relationship between hemodynamic instability and the catecholamine response is not fully understood. Weinger, et al. documented that ECT results in significant increases in blood pressure and circulatory norepinephrine and epinephrine levels[8].

The local skin blood flow has been reported to be controlled by the sympathetic nervous system[9]. The digital skin blood flow (DBF) measured by laser

Doppler flowmetry reflects the changes in concentration of the circulating catecholamine[10]. Accordingly, we examined the relationship between the changes in hemodynamics and the digital skin blood flow during ECT under propofol anesthesia.

Methods

Electroconvulsive therapy (ECT) was conducted in 7 patients in the operating room. All patients received antidepressants in the morning of ECT procedure and fasted overnight before ECT of the next morning. Following an intramuscular injection of atropine 0.4～0.5 mg 30 min before the procedure, propofol 1 mg/kg was intravenously administered for induction of anesthesia. After the patients were asleep, succinylcholine 1 mg/kg was injected for muscle relaxation, and then the patients were ventilated with 100 % oxygen under mask. A limb was isolated with the aid of a pneumocuff tourniquet. Movements during the seizure were monitored through the isolated leg. Through the bilateral, frontally placed stimulators, ECT stimulation (100V) was applied for 5 sec, which consisted of a single electrical stimulus.

All patients were continuously monitored by ECG and pulse oxymetry with the aid of an automatic blood pressure apparatus (Datex AS3, IMI Japan, Tokyo). A laser Doppler flowmeter (ALF 2100, Advance, Tokyo, Japan) with a plate-type probe attached to the palmar side of the first finger tip with a double-sided adhesive disk tape was employed for continuous measurement of the skin blood flow. The flowmetric data were recorded by a heat pen recorder. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and the digital skin blood flow (DBF) were measured before induction anesthesia (baseline), before, immediately after, and 10 min after the ECT procedure. Data are expressed as percent changes ± SD of mean from the baseline. Data were compared by an analysis of variance with Bonferroni correction for multiple comparisons. Correlations between changes in digital skin blood flow and changes in hemodynamic values (SBP, DBP, and HR) were assessed by a linear regression. Values where $p<0.05$ were considered statistically significant.

Six patients were major depressive disorder (n = 6) and one was schizophrenia (n = 1). The mean age, weight and height were 60.4 years (SD: 4.0) , 48.0 kg (SD: 10.9) and 149.0 cm (SD 4.7). The mean dose of propofol and succinylcholine were 1.3 mg/kg (SD: 0.2) and 1.0 mg/kg (SD: 0.1).

Results

Fig. 1 shows a typical response of the DBF recorded by the laser Doppler flowmeter during ECT under propofol anesthesia. Administration of propofol did not affect hemodynamics before ECT. Immediately

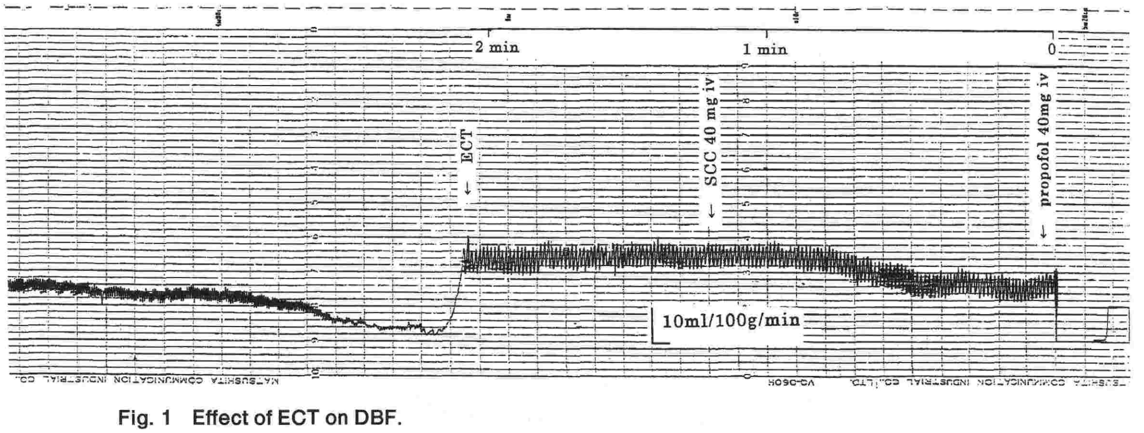

Fig. 1 Effect of ECT on DBF.
DBF decreased abruptly immediatery after ECT and recovered gradually within a few minutes.
ECT : electroconvulsive therapy, DBF : digital skin blood flow

after ECT, however, both SBP and DBP increased significantly from the baseline and the before ECT levels (Table 1 and fig. 2). Conversely, the DBF decreased significantly from the baseline value. Change of HR were not significant after ECT. All hemodynamic values, except HR, returned to the before ECT levels 10 min after ECT. In 4 patients, SBP rose up to 180 mmHg after ECT procedure, but an intravenous administration of nicardipine 0.5-1.0 mg successfully stabilized it.

Fig. 3 shows the extent of increases in SBP, DBP and HR in relation to that of decreases in the DBF. There was a statistically significant linear correlation between the increase in SBP and the decrease in the DBF ($r=0.62$; $p<0.001$) and between the increase in DBP and the decrease in the DBF ($r=0.62$; $p<0.001$), but not between changes in HR and the DBF.

Discussion

This study demonstrated that ECT causes hemodynamic deterioration and also interferes with digital circulation under propofol anesthesia. The hemodynamic liability results from the sympathetic and parasympathetic outputs after an electric shock was administered, as well as during the ensuring

Table 1 Hemodynamics during electroconvlusive therapy under propofol anesthesia

	Baseline	Befoere ECT	ECT	After ECT
Systolic blood pressure (mmHg)	129±18	124±22	178±23*,#,‡	127±15
Diastolic blood pressure (mmHg)	78±11	82±19	118±17*,#,‡	72±10
Heart rate (beats/min)	93±15	94±14	107±16	104±16
Digital skin blood flow (ml/100g/min)	11± 7	23±14	5± 3#	19±15

Data are mean±SD. N=7 * : $p<0.05$ vs baseline, # : $p<0.05$ vs before ECT, ‡ : $p<0.05$ vs after ECT

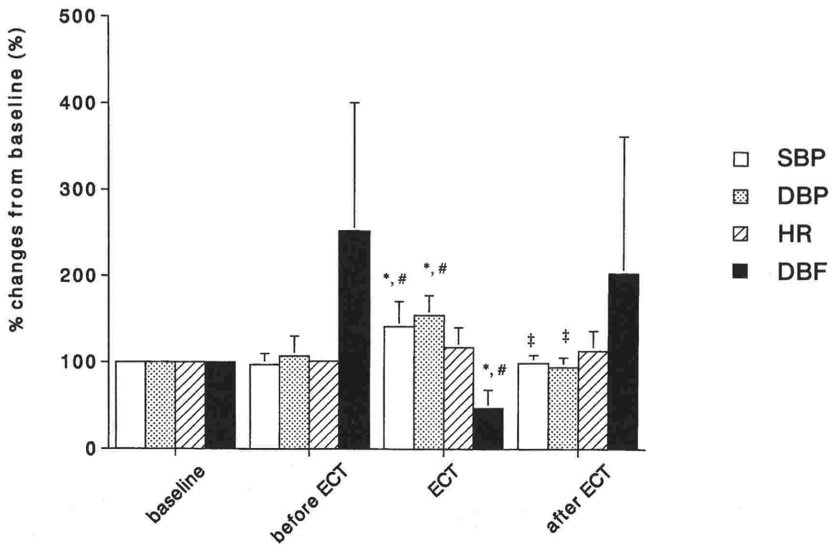

Fig. 2 Percentage changes of hemodynamics and DBF during ECT from baseline
*$p<0.05$ vs baseline, # : $p<0.05$ vs before ECT, ‡ : $p<0.05$ vs after ECT.
DBF : digital skin blood flow, ECT : electroconvulsive therapy

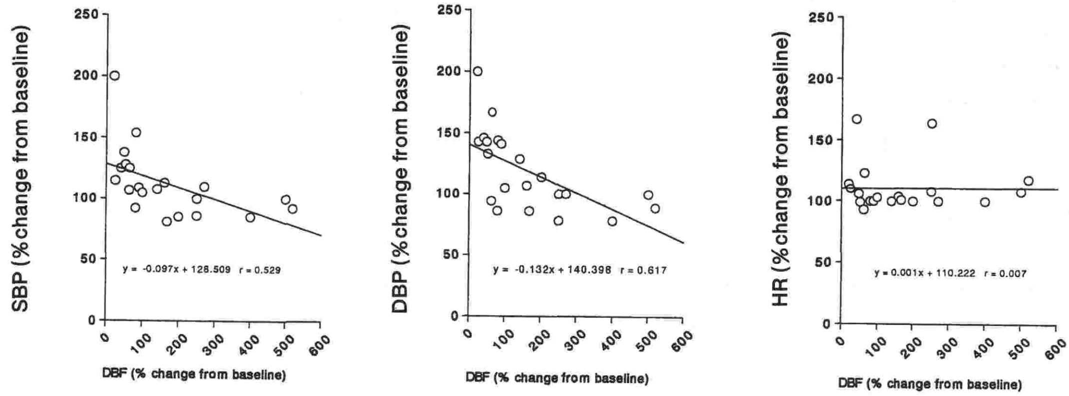

Fig. 3 Correlations of DBF with SBP, DBP and HR during ECT.
SBP and DBP correlated significantry with DBF ($p < 0.001$) but HR did not correlate with DBF.
DBF : digital skin blood flow, SBP : systolic blood presure, DBP : diastolic blood pressure, HR : heart rate, ECT : electroconvulsive therapy,

seizure[11]. Accordingly, for elderly patients who are at risk of cardiovascular or cerebrovascular complications, ECT may result in severe cardiac or neurological sequelae. Zielinski, et al. showed that the patients with heart disease suffered a significantly higher rate of cardiac complications during ECT than those without heart disease[12].

Messina, et al. reported a 45% incidence of echocardiographic hypokinesis during ECT, suggesting that ECT may induce demand of myocardial ischemia which express as, regional wall motion abnormalities on an echocardiography[13].

The cardiovascular response to ECT results from stimulation of the autonomic nervous system[14]. The increases in sympathetic activity result in exaggerated increases in circulating catecholamine levels. A good correlation between systolic arterial pressure and plasma norepinephrine levels has been demonstrated[8]. In our study, systolic and diastolic blood pressures showed an inverse relationship with digital skin blood flow. Our results may indicate an agreement with the previous work on hemodynamics and catecholamine response[8,11], if we assume that sympathetic nervous discharge affects digital skin blood flow. The vascular supply to the digital skin is characterized by abundant arteriovenous anastomoses, innervated by sympathetic fibers. The blood flow to the skin and body temperature are regulated by the sympathetic system, and a rapid sympathetic stimulation alters the blood flow to the digital skin. Accordingry, the measurement of the digital skin blood flow may be useful in determining the sympathetic activity. Laser Doppler flowmetry is a new and noninvasive method for measuring the superficial capillary flow in tissue. It has been shown that the cautaneous laser Doppler flow measurements correlate well with the results obtained from venous occlusion plethysmography[15]. Sakuragi, et al. described that the skin blood flow to the toe, measured by a laser Doppler flowmtery, closely followed rapid changes in plasma catecholamine concentration in patients undergoing extirpation of pheochromocytoma[10]. Thus, in our study, the digital skin blood flow measured by a laser Doppler flowmeter may be acceptable to be an index to represent a change in sympathetic activity during ECT. The digital skin blood flow was rapidly reduced immediately after ECT and restored within the subsequent few minutes. This change may be due to the sympathetic effects induced by the ECT procedure.

Other factors that may affect the digital skin blood flow should also be considered; the direct effect of electrical stimulation and seizure on cardiovascular system, the vasodilating effects of propofol and nicardipine, and the effect of chronic administration of antidepressants. Because the digital skin blood flow was determined under full muscle relaxation with succinylcholine, and the digital skin blood flow remained reduced after cessation of the convulsive state, skeletal muscle contraction mediated by a direct electromechanical stimulation of ECT may not be a direct cause of the reduction in the digital skin blood flow.

The better improvement of hemodynamic stability after administration of propofol has been reported than the administration of methohexital[16] or thiopental[17]. Propofol 1 mg/kg applied in their study was similar to ours. Propofol inhibits the sympathetic neuronal activity, decreases the sensitivity of the baroreflex and vasaodilates during surgery[18]. Thus propofol should increase the digital skin blood flow, at least theoretically.

Nicardipine has a potent vasodilative effect[19] and is used to reduce blood pressure in a hypertensive crisis. Like propofol, it also increases the digital skin blood flow. In this study, it was administered to 4 patients after ECT to reduce blood pressure. Therefore, nicardipine might not affected the reduction of the digital skin blood flow immediately after ECT.

Tricyclic antidepressants release norepinephrine[1,14] and may cause exaggerated vasoconstriction during ECT. They may potentiate the effect of ECT to reduce the digital skin blood flow. The explanation for the abrupt reduction of digital skin blood flow was most likely the release of catecholamine caused by ECT.

Because it appeared in our study that vasoconstriction dominated the chronotropic action after ECT, the lack of correlation between heart rate and the digital skin blood flow might be explained by a difference in the catecholamine response on the circulation system.

Our results suggest that the digital skin blood flow reflects the sympathetic nervous activity during ECT. Monitoring the digital skin blood flow will be useful in detecting transient changes in the sympathetic response during the ECT procedure. Alternatively, it should be noted that the administration of cardiovasoactive drugs makes it difficult to evaluate the sympathetic nervous system from the digital skin blood flow measurement.

References

1) Sutor B, Rummans TA, Jowsey SG, et al : Major depression in medical ill patients. Mayo Clin Proc 73 : 329-337, 1998
2) Philibert RA, Richards L, Lynch CF, et al: Effect of ECT on mortality and clinical outcome in geriatric unipolar depression. J Clin Psychiatry 56 : 390-394, 1995
3) Zisook S, Downs NS : Diagnosis and treatment of depression in late life. J Clin Psychiatry 59 : S80-91, 1998
4) Morris PL, Robinson RG, Andrejewski P, et al: Association of depression with 10 year poststroke mortality. Am J Psychiatry 150 : 124-129, 1993
5) Frasure-Smith N, Lesperance F, Talajic M : Depression following myocardial infarction. JAMA 270 : 1819-1825, 1993
6) Weinger MB, Partridge BL, Hauger R, et al : Prevention of the cardiovascular and neuroendocrine response to electroconvulsive therapy: I. effectiveness of pretreatment regimens on hemodynamics. Anesth Analg 73 : 556-562, 1991
7) Steiner LA, Drop LJ, Castelli I, et al : Diagnosis of myocardial injury by real-time recoding of ST segments of the electrocardiogram in a patients receiving general anesthesia for electroconvulsive therapy. Anesthesiology 79 : 383-388, 1993
8) Weinger MB, Partridge BL, Hauger R, et al : Prevention of the cardiovascular and neuroendocrine response to electroconvulsive therapy: II. effect of pretreatment regimens on catecholamines, ACTH, vasopressin, and cortisol. Anesth Analg 73 : 563-569, 1991
9) Nagasaka T, Hirata K, Nonomura T : Partitional measurements of circulation can be made between capillaries and arterovenous anastomoses in the human finger. Jpn J Physiol 38 : 67-75, 1988
10) Sakuragi T, Okamoto I, Fujiki T, et al : Skin blood flow and plasma catecholamine during removal of pheochromocytoma. Anesthesiology 85 : 1485-1488, 1996
11) Gravenstein JS, Anton AH, Wiener SM, et al : Catecholamine and cardiovascular response to electro-convulsion therapy in man. Br J Anaesth 37 : 833-839, 1965
12) Zielenski RJ, Roose SP, Devanand DP, et al : Cardiovascular complications of ECT in depressed patients with cardiac disease. Am J Psychiatry 150 : 904-909, 1993
13) Messina AG, Parancias M, Katz B, et al : Effects of electroconvulsive therapy on the electrocardiogram and echocardiogram. Anesth Analg 75 : 511-514, 1992
14) Marks RJ : Electroconvulsive therapy: physiological and anaesthetic considerations. Can Anaesth Soc J 31 : 541-548, 1984
15) Winsor T, Haumschild DJ, Winsor DW, et al : Clinical application of laser Doppler flowmetry for measurements of cutaneous circulation in health and disease. Angiology 38 : 727-736, 1987
16) Dwyer R, McCaughey W, Lavery J, et al : Comparison of propofol and methohexitone as anaesthetic agents for electroconvulsive therapy. Anaesthesia 43 : 459-462, 1988

17) Boey WK, Lai FO : Comparison of propofol and thiopentone as anaesthetic agents for electroconvulsive therapy. Anaesthesia 45 : 623-628, 1990
18) Thomas EJ, Michael M : Propofol and autonomic reflex function in humans. Anesth Analg 78 : 369-375, 1994
19) Hersey SL, O'Dell NE, Lowe S, et al: Nicardipine versus nitroprusside for controlled hypotension during spinal surgery in adolescents. Anesth Analg 84 : 1239-1244, 1997

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