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表3　戦争と外傷治療の変遷

戦争	医学史上の出来事	年	患者搬送	おもな死因	外科的問題	外傷治療の状況	外傷治療の進歩
第一次世界大戦		1914～1918	人馬・自動車	外傷	高度な組織挫滅・多発外傷	大戦勃発以前は四肢外傷以外は外科治療の対象と考えられていなかった	デプリドマンなどの外傷治療の基本方針確認(1917)，体幹外傷の外科治療の進歩
	Fleming：ペニシリンの効果報告	1940					
第二次世界大戦		1939～1945	自動車，飛行機	外傷	出血性ショック	抗生物質の使用，アメリカ軍における戦傷者の院内死亡率は4.5％	ショックの病態解明が進む，血液銀行設立，熱傷治療の進歩，呼吸生理の解明
朝鮮戦争		1950～1953	自動車，飛行機	外傷	急性腎不全	アメリカ軍における戦傷者の院内死亡率は2.5％	血管外科の進歩
	心拍出量の調節機構，換気・血流比の解明など呼吸循環生理の進歩	1950年代					医科学の進歩により外傷に伴う病態解明と治療法開発が進んだ
ベトナム戦争		1954～1975	ヘリコプター	外傷	急性呼吸不全	アメリカ軍における戦傷者の院内死亡率は1.8％	Trauma Centerの原型確立（ヘリコプター搬送とearly definitive care）

映しているのかもしれない．

多臓器不全 (multiple organ failure：MOF)

外傷外科学が20世紀の戦場から学習したのは，ヒトは外傷に伴う組織損傷から心不全に陥り死亡すること（第一次世界大戦，wound toxinと考えられたが，1930年代には外傷性ショックとして認識された），出血性ショックは乳酸リンゲル液と血漿成分の投与により蘇生できること（第二次世界大戦），出血に対し輸液・輸血による蘇生が不十分な場合は急性腎不全を発症し致死的となること（朝鮮戦争），出血性ショックに対し十分な蘇生を行えば急性腎不全を予防できるが急性呼吸不全を続発するということ（ベトナム戦争）であった（表3）．これらの成果は臨床的問題を基礎医学の知識で科学的に解明し，さらにあらたな治療法の開発に結びつけ臨床に還元するというサイクルが効果的に繰り返された結果である．

アメリカでは1970年代前半の集中治療室の増加に伴い，新しい臓器サポートの方法（Swan-Ganzカテーテル，定量式人工呼吸器，完全静脈栄養，血液透析など）が続々と導入され，重症患者が単一臓器不全（心不全，腎不全，呼吸不全）で死亡することは少なくなった．このような状況で医師があらたに遭遇するようになったのがmultiple organ failure（MOF；多臓器不全）とよばれる病態である[10]．EisemanがMOFをあらたな“man-made syndrome”とよんでいるように，治療医学の進歩とMOFはコインの表裏の関係あるといえる[11]．

ARDSとMOFはあらたな病態として注目されたが，当初これらの病態と外傷の関連性はよくわかっていなかった．1977年Eisemanらは“Multiple organ failure”と題する論文でMOFに陥った外傷を含む術後患者42例の検討を行い，その半数で腹腔内感染症がMOFの誘因と考えられるとした[11]．また，Fryらは1980年に“Multiple Organ System Failure——The Role of Uncontrolled Infection”と題する論文で，術後患者に発生するMOFの原因は合併症としての重症感染（胸腔，腹腔，軟部組織）であるとし，“MOSF is the most common fatal expression of uncontrolled infection”であると述べた[12]．これらの研究により1970

年代後半および1980年代前半は，ARDSあるいはMOFは“外傷→引き続く感染症→ARDS/MOF”という仮説で説明されるようになった．しかし，実際に患者がMOFに陥った場合，当時のセオリーに従って感染巣を検索しても明らかな感染巣を見出せない場合や，すでに外科的ドレナージが施行されている症例も存在し，“MOF＝感染症説”が万能でないことはしばしば経験されていた．Tilneyらは1973年に腹部大動脈瘤破裂の手術後に発生する“sequential system failure”を報告し，そのなかでMOFの誘因は心血管系の基礎疾患と外科的操作に伴う機械的・代謝的な結果であると推測しているが，感染症の関与については触れていない[13]．この報告は当時主流となっていた“MOF＝感染症説”だけではMOFを説明できないことを示しているが，“MOF＝感染症説”にとってかわる考え方が提出されたのは1980年代後半であった．

1985年Gorisらは，“MOF —— Generalized Autodestructive Inflammation?”と題する論文で，“MOF＝感染症説”にとってかわる“MOF＝全身性炎症反応説”を提出した[14]．彼らは，外傷に伴う組織破壊，あるいは感染症に惹起される炎症反応が全身に及ぶと重要臓器の機能不全，すなわちMOFが起こると考えた．これは，MOFに陥った患者で感染巣を検索しても明らかな原因が見出せない症例や，感染巣を外科的に処置してもMOFが進行する症例の病態を説明するのに妥当な仮説であり，臨床の場に広く浸透していった．

一方，敗血症（sepsis）の臨床研究に関連して1992年“systemic inflammatory response syndrome (SIRS)”の概念が提唱された[15]．これは感染症（細菌，真菌，ウイルス，寄生虫すべてを含む），外傷による組織損傷（熱傷を含む），非感染性炎症（急性膵炎など）を生体に対する侵襲としてとらえ，これらによって惹起される炎症が全身に及ぶものをSIRSとして定義した．また，MOFのF：failure（機能不全）はすでに回復のチャンスが少ない臓器不全を連想させることと，機能不全を診断してもすでに手遅れとの考え方からmultiple organ dysfunction syndrome（MODS）としてD：dysfunction（機能障害）を早期に診断することが強調されるようになった．

外傷に対する生体の全身性炎症反応と続発症

生体に侵襲が加わると，生体は一連の反応を示す．局所の炎症反応は局所に侵襲が加わったことにより起こるが（打撲や骨折による局所の腫脹，感染による皮下膿瘍など），侵襲が大きい場合は生体の炎症反応は局所にとどまらず全身に及ぶ（全身性炎症反応）．そして全身の炎症反応が高度であれば，各種臓器の機能障害（MODS）を起こし最悪の場合には死に至る．これが侵襲とそれに対する生体反応とSIRS・MODSの基本的な仮説である．“侵襲の大きさと生体反応”というアイデアはすでにMoore (Moore,F.D.)が『Metabolic Care of the Surgical Patient』(1959)で述べているが，現在は侵襲の“大きさ”をサイトカインなどのメディエーターや化学反応物質として測定し数値で推定できるようになったことが大きく異なる．

1983年Faistらは多発外傷患者433例に続発するsingle organ failure（SOF）とMOFの臨床的検討を論文として発表した[16]．彼らは，臓器としてはまず肺が障害されること，臓器障害が起こるパターンにrapid single-phase MOFとdelayed two-phase MOFの2型があること，また前者では出血性ショックが，後者では感染が大きく関与していることを示した．また，Moore (Moore,F.A.)らは1995年にInjury Severity Score（ISS）が15以上の外傷例を分析し，外傷後のMOFの発生パターンにはearlyとdelayedの2型があることを報告している[17]．Mooreらは，early型のMOFは外傷そのものの侵襲が過大な一撃となり発症するのに対し(one-hit model)，delayed型は外傷により引き起こされたSIRSが別な侵襲が加わることで増強され発症すると考えた（second-hit model）（図1）．これを外傷後の時間経過で展開すると図2になる[18]．すなわち，外傷による一次損傷が炎症性メディエーターの産生を引き起こし，SIRSが惹起されることとなる．生体は炎症性メディエーターをカウンターバランスするために抗炎症性サイトカインを産生するが，これは生体の免疫機能を抑制する．この2つの状態がバラン

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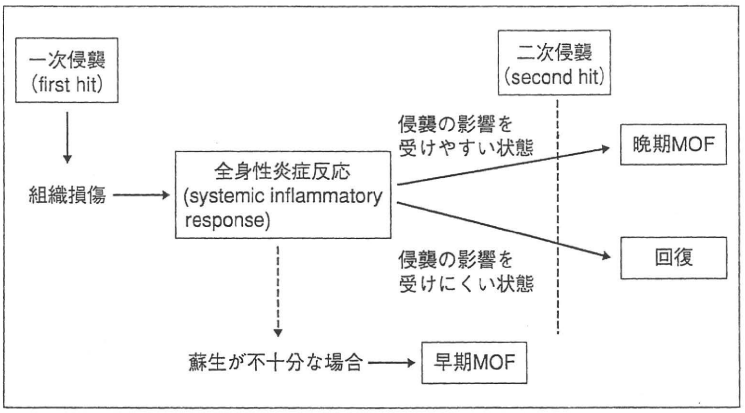

図1　炎症モデル（文献[18]より改変）

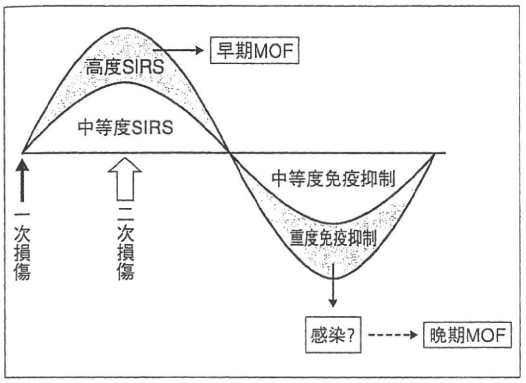

図2　Mooreらの臓器障害発生機序の仮説

スよく起こる場合，生体は侵襲に対し恒常性を維持できることになるが，免疫抑制が強くなると感染性合併症が起こる危険性が高まる．さらに，一次損傷が加わった後に二次損傷（低酸素血症やショックの遷延，再出血，止血のための外科的操作など）が起こると全身性炎症反応が増強され，それに引き続く免疫抑制も高度となる．この仮説では早期MOFは重症SIRSで，晩期MODSはSIRSに続発する免疫抑制期に感染症などを合併することにより発症すると説明される．

以上の仮説を外傷にあてはめると，一次損傷が高度なほど，また二次損傷が加わるほどARDS/MODSが発症しやすいということになる．これまで報告されている外傷後のARDSのリスクファクターは外傷そのものが重症であることと，それ以外にも年齢（高齢）[19]，性差（男性），APACHEスコア（高値），ISS（高値）[20]，輸血量（大量[21]，入院48時間以降の投与[22]），輸液量（大量），気道内圧（高値）[23]などがあげられている．これらが意味しているのは，重度外傷ほどARDSのリスクは高いということであるが，臨床的には重度外傷に対する初期治療または絶対的な外科治療が不十分であれば，それは二次損傷となってSIRSあるいはそれに引き続く免疫抑制状態を増強し，結果的にARDS/MODSのリスクをさらに高めることを意味する．現実的には一次損傷を修飾することは不可能なので，ARDS/MODSを防止するという観点では初期治療による蘇生を十分に行い，絶対的な外科治療をタイミングよく確実に行うことが肝要となる．たとえば，長管骨骨折の場合，初期には一時的な固定（創外固定を含む）のみを行い，その2〜3日後に観血的内固定を実施することで，外傷後ARDSの発症率を減じることができたと報告されている[24]．また二次損傷をいかに軽減させるかも重要であり，過剰輸液の抑制や輸血時の白血球除去などにより，二次損傷後のARDS発症率を低下させることが可能であったとの報告もある[25]．

外傷後ARDSの予後については，死亡率がいぜんとして高いという報告がある一方，死亡率はISSの重症度と相関はしていたが，ALI/ARDSの合併とは関連がみられなかったという報告[26]や重度頭部外傷を合併した鈍的外傷患者においてもARDSを併発した群で死亡率や障害の程度に影響はなく，合併症の発症率，ICU滞在期間や入院期間の延長と関連していたという報告がある[27]．

現在こうした外傷後ARDSの管理方法については，肺保護戦略に則った人工呼吸管理[22]，間欠的な腹臥位管理[28]，体外式膜型人工肺（extracorporeal membrane oxygenation：ECMO）などが試みられている．ECMOについては，外傷患者への応用は議論のあるところだが，機器や技術の進歩により重症胸部外傷を伴う多発外傷後ARDS患者に導入し，出血や下肢虚血の合併症を増やすことなく，酸素化や循環動態を改善できたと報告されるようになってきた[29]．肺保護戦略に基づいた人工呼吸管理では，低酸素血症が進行するような外傷後ARDS患者では人工呼吸器による二次肺損傷を防ぎ，ガス交換の改善を図るためにECMOの早期導入も“Lung rest”を考慮した治療のオプションとして考えていいのかもしれない．

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SCIENTIFIC ARTICLE

Percutaneous Carpal Tunnel Release Compared With Mini-Open Release Using Ultrasonographic Guidance for Both Techniques

Ken-ichi Nakamichi, MD, Shintaro Tachibana, MD, Seizo Yamamoto, MD, Masayoshi Ida, MD

Purpose To compare the outcomes of percutaneous carpal tunnel release (PCTR) and mini-open carpal tunnel release (mini-OCTR) using ultrasonographic guidance for both techniques.

Methods We included 74 hands of 65 women with idiopathic carpal tunnel syndrome (age, 52–71 y; mean, 58 y). Thirty-five hands of 29 women had the PCTR (release with a device consisting of an angled blade, guide, and holder, along a line midway between the median nerve and ulnar artery (safe line) under ultrasonography (incision, 4 mm), and 39 hands of 36 women had the mini-OCTR (release along the safe line, distally under direct vision (incision, 1–1.5 cm) and proximally under ultrasonography, using a device consisting of a basket punch and outer tube.

Results Assessments at 3, 6, 13, 26, 52, and 104 weeks showed no significant differences in neurologic recovery between the groups ($p > .05$). The PCTR group had significantly less pain, greater grip and key-pinch strengths, and better satisfaction scores at 3 and 6 weeks ($p < .05$), and less scar sensitivity at 3, 6, and 13 weeks ($p < .05$). There were no complications.

Conclusions The PCTR provides the same neurologic recovery as does the mini-OCTR. The former leads to less postoperative morbidity and earlier functional return and achievement of satisfaction. *(J Hand Surg 2010;35A:437–445. © 2010 Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand.)*

Type of study/level of evidence Therapeutic III.

Key words Carpal tunnel release, carpal tunnel syndrome, minimally invasive surgery, mini-open technique, percutaneous technique, ultrasonography.

FOR THE SURGICAL treatment of carpal tunnel syndrome (CTS), 3 options are available: open carpal tunnel release (OCTR), endoscopic carpal tunnel release, and mini-open carpal tunnel release (mini-OCTR).[1,2] The OCTR has been used for a long time and is considered safe and simple, although it is associated with weakness, pillar pain, and a long scar. In an effort to solve these problems, the endoscopic carpal tunnel release was developed. Although it has demonstrated less postoperative morbidity and early return to work and activities of daily living, concerns persist over complications as well as cost. As an alternative to reduce surgical trauma, the mini-OCTR has been proposed. It has closely matched the endoscopic carpal tunnel release in the functional return and decrease in pillar pain, but there still is a concern that part of the procedure is performed blindly.[1,2]

We have used the OCTR (incision from just distal to Kaplan's cardinal line to the wrist crease) for a long

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The device in the manuscript was designed by one of the authors (K.N.), patented, and manufactured by Futaba Co., Ltd. (Tokyo, Japan). This author has financial involvement (patent, royalties) with Futaba Co., Ltd.

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time and recently the mini-OCTR (incision 1.0–1.5 cm at the distal carpal tunnel) in selected patients. For the latter, we use ultrasonography to protect the critical structures.[3] This provided the same neurologic improvement as the OCTR and better early outcomes regarding pain, scar tenderness, and grip and key-pinch strengths than the OCTR.[3] The difference was attributed to the limited dissection. We then hypothesized that further reduction of surgical trauma could improve the outcome of the mini-OCTR, and we developed a percutaneous carpal tunnel release (PCTR) technique , also using ultrasonography. Although a different ultrasonographically assisted percutaneous release was performed by Rowe et al. in cadavers, to our knowledge, it has not been evaluated clinically.[4] The purpose of this study was to compare the outcomes of the PCTR and mini-OCTR, using ultrasonographic guidance for both techniques.

MATERIALS AND METHODS

Selection of patients

We included 74 hands of 65 women, all homemakers (age, 52–71 y; mean, 58 y), with idiopathic CTS, who were candidates for either of the 2 ultrasonographically assisted carpal tunnel release techniques, the PCTR or mini-OCTR. They initially visited the orthopedic clinic of our institute between November 2001 and March 2007. Two orthopedic surgeons performed the clinical examination. The patients had either thenar muscle weakness or intractable sensory symptoms with poor response to nonsurgical treatment for at least 3 months, including avoidance of overuse, splinting, or local steroid injection. We included this group of patients to provide a uniform model or to eliminate factors related to work and contributory medical conditions.

The diagnosis of CTS was made clinically and electrophysiologically. The clinical evaluation included questioning about sensory symptoms, tests for sensibility and muscle strength, and examination for thenar atrophy. We performed Phalen's test and, if this was negative, reverse Phalen's test (mirror image of Phalen's test). We also checked for Tinel's sign on percussion of the wrist. However, we did not rely solely on these tests to make the diagnosis, considering possible false positive results.

Electrophysiologic studies were performed by 1 examiner in the department of neurophysiology. The criteria for the diagnosis of CTS were a median distal motor nerve latency of greater than 4.2 ms (stimulation, 2 cm proximal to the wrist crease) or a median sensory nerve conduction velocity (between the middle crease of the long finger and 2 cm proximal to the wrist crease) of less than 45 m/s. Patients with findings of a median nerve supplying the hypothenar muscle[5] and an ulnar sensory nerve supplying the third web space[6] were excluded, because these anomalies were contraindications for both techniques.

This study was approved by the internal review board of our institute, and an informed consent was obtained from all the patients before surgery.

Selection of surgical technique

One orthopedic surgeon, who was the most experienced in ultrasonography among the authors, determined the surgical technique for each patient. He obtained axial ultrasonographic images of the carpal tunnel and measured the distance between lines drawn vertical to the transverse carpal ligament (TCL) at the ulnar margin of the median nerve and the radial margin of the ulnar artery. The zone in the TCL between the lines was defined as the *safe zone*.[7]

The mini-OCTR was performed when the safe zone was greater than 3 mm at the proximal carpal tunnel. Unlike the previous report,[7] a distal narrow zone (3 mm or less) was not considered a contraindication because, at the time of distal release, the median nerve and ulnar artery could be protected under direct vision. In contrast, the PCTR was performed when the zone was greater than 3 mm at any level. The PCTR was not performed if ultrasonography showed a hypertrophic flexor pollicis brevis or palmaris brevis[8] extending into the safe zone.

Based on these evaluations, 35 hands (29 women) had the PCTR, and 39 hands (36 women) had the mini-OCTR. The mean age was 56 years (range, 52–71 y) in the PCTR group and 59 years (range, 54–70 y) in the mini-OCTR group. The mean duration of symptoms before surgery was 24 months (range, 4 mo to 20 y) in the former group and 29 months (range, 6 mo to 15 y) in the latter group.

Surgical Technique

PCTR: We used a cutting device consisting of an angled blade (single-use), guide, and holder (Futaba Co., Ltd., Tokyo). A pneumatic tourniquet was not used so that pulsation of the ulnar artery could be recognized. The procedure began with ultrasonographic location of the key structures. In longitudinal images, the TCL and superficial palmar arch (SPA) were identified. In axial images, the median nerve and ulnar artery were located. The entry point was marked on the palm, distal to the critical pillar rectangle,[9] at the intersection of the SPA and a line midway between the ulnar margin of the median nerve and radial margin of the ulnar artery (safe

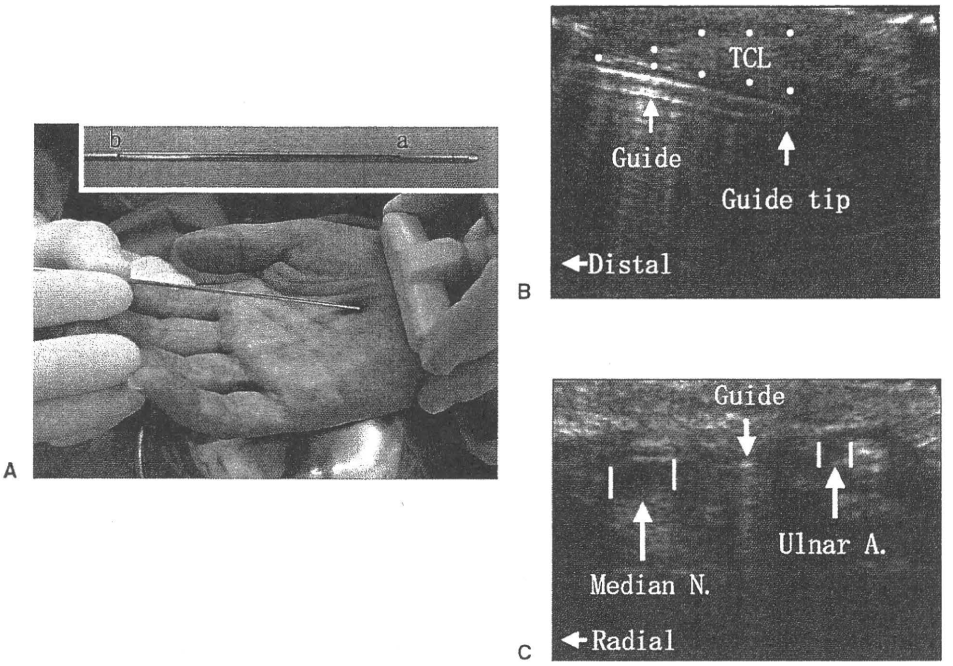

FIGURE 1: Insertion of the guide (14-cm long metal tube, 1.8-mm outer diameter). **A** It is inserted through the palmar aponeurosis, beneath the TCL, from its distal edge along the safe line under ultrasonographic monitoring. The guide has a slot (inset, a–b; 5 cm long, 1 mm wide) on the top, starting 1.5 cm from its tip (to right), to accommodate the blade. It is advanced into the tunnel for 1.5 cm to bring the slot end (inset, a) to the distal edge of the TCL. Proper positioning of the guide is confirmed by biplanar imaging. The guide, under which acoustic shadow is created, is recognized in a sagittal image **B** beneath the TCL (outlined by dots) and in an axial image **C** midway between the ulnar margin of the median nerve (Median N.) and the radial margin of the ulnar artery (Ulnar A.).

line). After administration of local anesthesia, a 4-mm incision was made at the entry point. Under ultrasonographic monitoring, the guide was inserted beneath the TCL, along the safe line (Fig. 1). The cutting device was assembled (Fig. 2). The TCL was divided as the device was advanced proximally, with its tip (blade) localized to the TCL along the safe line, under ultrasonographic monitoring. Release was done to exceed the level proximally, where the enlarged part of the nerve proximal to compression had the largest cross-sectional area, usually 5 to 10 mm proximal to the wrist crease. A single pass of the device completed the release. After device removal, release was confirmed by communication between the inside and the outside of the tunnel with a probe, under palpation or ultrasonography. Because the wound was small, it was not closed.

Mini-OCTR: A pneumatic tourniquet was not used for the same reason as for the PCTR. The distal edge of the TCL and safe line were ultrasonographically recognized and marked on the palm. A 1.0 to 1.5 cm skin incision was designed along the line, with its center crossed by the distal edge of the TCL. After administration of local anesthesia, the incision was made. The distal TCL was divided under direct vision. For proximal release, a device was used that consisted of a basket punch (2.7-mm outer diameter) and an outer metal tube (3.5-mm outer diameter). This was inserted through the incision beneath the TCL in a proximal direction, and the scanner was placed on the palm at the level of the tip of the punch. Under axial imaging, the device was localized along the safe line, and the proximal TCL was divided in a bite-by-bite fashion. The extent of proximal release was the same as in the PCTR. Release was confirmed distally under direct vision and proximally by communication between the inside and the outside of the tunnel with a probe, under palpation or ultrasonography. After irrigation, the wound was closed with monofilament sutures.[3]

Postoperative regimen

No splinting was used in either group. The patients were allowed to use the hand as tolerated. No hand therapy was prescribed. We examined them every 1 or 2 days for wound care and assessment. The wound was defined as healed in the PCTR group when it had complete closure, no discharge, and no separation with the hand opened (full active extension of digits and abduction of the thumb and little finger). In the mini-

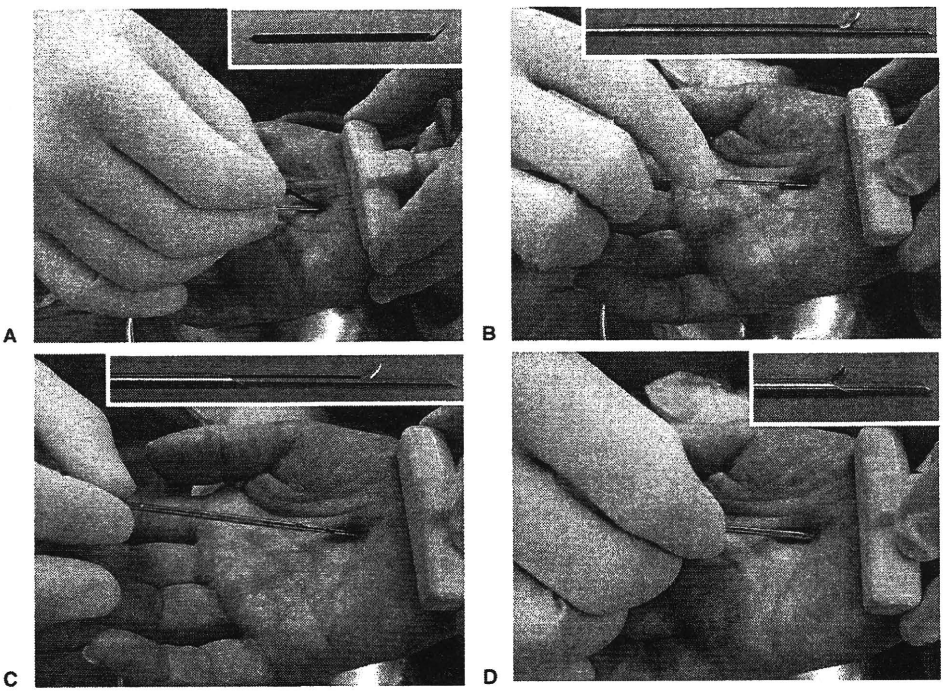

FIGURE 2: Device setup. **A** The cutting edge of a no. 138 blade (inset; 4 cm long, 0.9 mm wide, 4 mm high) is angled parallel to the guide and placed in the slot. Its tip is advanced into the subcutaneous tissue. **B** The blade base is turned downward and placed in the slot (inset). **C** The holder (11 cm long metal tube, 2.5-mm outer diameter) is applied (from left) to hold the blade and guide together (inset). **D** It is advanced to the final position. Inset shows the side view of the assembled device tip.

OCTR group, the sutures were removed 6 to 8 days after surgery, and then the open hand test was done to confirm healing.

Evaluation

The hands were examined before surgery and at 3, 6, 13, 26, 52, and 104 weeks after surgery by a hand therapist who was blinded to the techniques. Before each postoperative examination, the patients attached an adhesive, soft tape to the proximal palm to obscure the incision. All the hands—35 in the PCTR group and 39 in the mini-OCTR group—were evaluated at the initial time interval (before surgery), whereas 29 in the former group and 34 in the latter group were available for the evaluation at the final interval (104 weeks). The numbers of hands evaluated at each time interval are shown in Table 1.

Sensibility was quantified in the long finger by static 2-point discrimination and Semmes-Weinstein monofilament testing. The latter was scored as 1 (normal, 1.65–2.83), 2 (diminished light touch, 3.22–3.61), 3 (diminished protective sensation, 3.84–4.31), or 4 (loss of protective sensation, 4.56–6.65).

Motor tests included manual muscle testing of the abductor pollicis brevis (APB) (results graded 0–5), and grip and key-pinch measurements.

In addition, the following variables were recorded after surgery: pain scored as 0 (absent), 1 (mild, not bothering), 2 (moderate, somewhat bothering but not limiting daily activities), or 3 (severe, bothering and limiting daily activities), time to wound healing, scar sensitivity, and satisfaction (rated from 0 to 5 on a visual analog scale). The scar sensitivity was measured as described by Trumble et al.[10] A pressure meter with a 1.3-cm^2 base (Natume Inc., Tokyo) was applied to the distal, mid, and proximal (wrist crease) carpal tunnel, for 30 seconds at each location, and the lowest load that produced discomfort was recorded. This was also assessed before surgery, with loads of 3.0 kg.[10]

The electrophysiologic studies were performed again just before surgery in those who did not respond to the nonsurgical treatment because their data often became worse. After surgery, the studies were repeated at 13, 26, 52, and 104 weeks.

Statistical analysis

To compare data, we used Student's or Welch's *t*-tests or Mann-Whitney U tests, depending on the data type, normality, and variance. We used analysis of covariance for comparison at each time interval, and repeated-measures analysis of covariance to compare the results of the 2 groups. Hands that were not available for the

TABLE 1. Patient Cohort and Sensory Data

Preoperative Parameters	0 wk	3 wk	6 wk	13 wk	26 wk	52 wk	104 wk
Patient cohort*							
PCTR		35	35	33	33	31	29
Mini-OCTR		39	38	37	35	36	34
Static 2-point discrimination (mm)							
PCTR	11.9 ± 4.7	11.1 ± 4.3	8.9 ± 4.0	6.7 ± 2.9	5.9 ± 2.2	5.7 ± 1.7	5.1 ± 1.3
Mini-OCTR	12.1 ± 4.7	11.5 ± 5.2	10.0 ± 5.7	8.2 ± 4.6	6.7 ± 3.1	6.2 ± 2.8	5.9 ± 2.9
p value	.76	.19	.33	.08	.16	.31	.09
Semmes-Weinstein monofilament grade							
PCTR	3.3 ± 0.6	3.3 ± 0.6	2.9 ± 0.7	2.5 ± 0.7	2.2 ± 0.6	1.9 ± 0.7	1.6 ± 0.5
Mini-OCTR	3.1 ± 0.7	3.1 ± 0.7	3.0 ± 0.9	2.7 ± 0.9	2.3 ± 0.8	2.0 ± 0.7	1.7 ± 60.6
p value	.49	.10	.50	.23	.22	.10	.17

*Patient cohort shows numbers of hands evaluated and applies to all tables.

evaluation were excluded from the analysis. Variables were presented as mean and standard deviation. The reported p values were 2-tailed. The level of significance was $p<.05$. Power analysis (α error, .05; β error, .2) revealed that, with the sample size (35 hands in the PCTR group and 39 hands in the mini-OCTR group), the true difference should be as great as .66 times the standard deviation for continuous variables to detect a significant difference.

RESULTS

Study population

There were no significant differences between the groups with respect to age and duration of symptoms before surgery ($p>.05$ for each variable).

Wound healing

The wound healing time was significantly shorter ($p<.01$) in the PCTR group (mean, 1.4 d; range, 1–4 d) than in the mini-OCTR group (mean, 7.5 d; range, 6–10 d).

Sensory data

The static 2-point discrimination and Semmes-Weinstein monofilament grade are shown in Table 1. After surgery, the sensory variables significantly improved in both groups ($p<.01$ for each variable). There were no significant differences between the groups ($p>.05$ for each variable). The p values for these variables at each time interval are presented in Table 1.

The numbers of symptom-free hands in the PCTR and mini-OCTR groups were 7 (21%) and 10 (27%) at 13 weeks and 26 (90%) and 28 (82%) at 104 weeks, respectively.

Strength

Table 2 shows the APB power, grip strength, and key-pinch strength. Weakness of the APB was noted before surgery in 29 hands in the PCTR group and in 27 hands in the mini-OCTR group. It was graded as 0 before surgery and was not recovered at all at 104 weeks in 5 hands in the former group and in 6 hands in the latter group. The remaining hands showed significant improvement ($p<.01$ in both groups). We found no significant difference between the groups ($p=.59$). The grip and key-pinch strengths decreased significantly at 3 and 6 weeks in both groups ($p<.05$ for each variable). The patients stated that the strengths were limited by the pain. However, they were significantly greater in the PCTR group at 3 weeks ($p<.01$) and 6 weeks ($p<.05$). No significant differences between the groups were seen at later time intervals ($p>.05$). The p values for these variables at each time interval are presented in Table 2.

Pain and scar sensitivity

The pain and scar sensitivity are shown in Table 3. The PCTR group had significantly less pain than the mini-OCTR group at 3 and 6 weeks ($p<.01$ at each time interval). No significant differences between the groups were seen at later time intervals ($p>.05$). At 26 weeks, 3 hands in each of the groups still had mild pain, which was relieved completely by 52 weeks. Before surgery, the scar sensitivity assessment revealed no discomfort with loads of 3.0 kg in both groups. The scars were

TABLE 2. Strength

Preoperative Parameters	0 wk	3 wk	6 wk	13 wk	26 wk	52 wk	104 wk
APB power							
PCTR	2.5 ± 2.0	2.5 ± 2.0	2.8 ± 2.0	3.6 ± 1.7	3.9 ± 1.8	4.1 ± 1.8	4.3 ± 1.8
Mini-OCTR	2.5 ± 2.2	2.7 ± 2.0	3.1 ± 2.2	3.4 ± 2.3	3.6 ± 2.1	4.0 ± 1.8	4.0 ± 1.8
p value	.96	.97	.89	.37	.27	.34	.30
Grip strength (kg)							
PCTR	21.9 ± 3.8	18.2 ± 4.0	20.3 ± 4.2	22.6 ± 4.1	23.7 ± 4.4	24.3 ± 4.3	24.5 ± 4.6
Mini-OCTR	23.7 ± 5.2	15.3 ± 4.0	17.4 ± 4.1	21.7 ± 4.7	25.5 ± 5.6	25.0 ± 5.5	25.1 ± 5.7
p value	.10	<.01	<.01	.13	.33	.96	.99
Key-pinch strength (kg)							
PCTR	3.4 ± 1.2	2.7 ± 1.0	3.0 ± 1.1	3.5 ± 1.1	3.8 ± 1.1	4.0 ± 1.2	4.2 ± 1.2
Mini-OCTR	3.8 ± 1.1	2.4 ± 1.0	2.8 ± 1.1	3.9 ± 1.2	4.2 ± 1.1	4.4 ± 1.1	4.5 ± 1.1
p value	.10	<.01	.04	.78	.64	.48	.34

TABLE 3. Pain, Scar Sensitivity, and Patient Satisfaction

Preoperative Parameters	0 wk	3 wk	6 wk	13 wk	26 wk	52 wk	104 wk
Pain							
PCTR	0.0 ± 0.0	1.4 ± 0.5	0.9 ± 0.4	0.4 ± 0.6	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
Mini-OCTR	0.0 ± 0.0	2.1 ± 0.7	1.4 ± 0.8	0.5 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
p value		<.01	<.01	.45	.89		
Scar sensitivity (kg)							
PCTR	3.0 ± 0.0	1.2 ± 0.4	1.8 ± 0.5	2.3 ± 06	2.7 ± 0.4	3.0 ± 0.0	3.0 ± 0.0
Mini-OCTR	3.0 ± 0.0	1.0 ± 0.4	1.4 ± 0.5	1.8 ± 0.5	2.6 ± 0.4	3.0 ± 0.0	3.0 ± 0.0
p value		.03	<.01	<.01	.15		
Patient satisfaction							
PCTR		3.7 ± 0.4	3.9 ± 0.2	4.3 ± 0.4	4.4 ± 0.5	4.7 ± 0.5	4.8 ± 0.4
Mini-OCTR		3.1 ± 0.3	3.4 ± 0.5	4.1 ± 0.5	4.5 ± 0.5	4.6 ± 0.5	4.7 ± 0.5
p value		<.01	<.01	.24	.62	.47	.36

significantly less sensitive in the PCTR group at 3 weeks ($p=.03$), 6 weeks ($p<.01$), and 13 weeks ($p<.01$). No significant differences between the groups were seen at later time intervals ($p>.05$). The p values for these variables at each time interval are presented in Table 3.

Patient satisfaction

The patient satisfaction is shown in Table 3. The score was significantly better in the PCTR group at 3 and 6 weeks ($p<.01$ at each time interval). No significant differences between the groups were seen at later time intervals ($p>.05$). The p value at each time interval is presented in Table 3.

Electrophysiologic data

Table 4 shows the electrophysiologic results. Motor potentials were undetectable before surgery in 12 hands in the PCTR group and in 16 hands in the mini-OCTR group. It was still undetectable at 104 weeks in 5 hands in the former group and in 6 hands in the latter group. The remaining hands showed significant improvement ($p<.01$ in both groups). Sensory potentials were undetectable before surgery in 19 hands in the PCTR group and in 22 hands in the mini-OCTR group. At 104 weeks, it was still undetectable in 2 hands in the former group and in 1 hand in the latter group. In these hands, motor potentials were also undetectable throughout the course, but there was relief of sensory symptoms. The remaining

TABLE 4. Electrophysiologic Data*

Preoperative Parameters	0 wk	13 wk	26 wk	52 wk	104 wk
Median distal motor latency (ms)					
PCTR	6.3 ± 1.6	4.7 ± 0.7	4.2 ± 0.5	4.0 ± 0.4	3.8 ± 0.4
Mini-OCTR	6.6 ± 1.7	4.8 ± 0.9	4.3 ± 0.7	4.0 ± 0.5	4.0 ± 0.5
p value	.65	.58	.32	.12	.64
Median sensory conduction velocity (m/s)					
PCTR	27.8 ± 6.0	36.0 ± 4.0	38.3 ± 4.2	40.1 ± 4.5	42.3 ± 4.2
Mini-OCTR	27.0 ± 7.7	38.2 ± 4.3	40.5 ± 4.3	43.6 ± 4.5	43.9 ± 4.2
p value	.76	.60	.13	.19	.94

*The hands in which preoperative potentials were undetectable were not included in the statistical analysis.

hands showed significant improvement ($p<.01$ in both groups). We found no significant differences between the groups ($p>.05$ for each variable). The p values for both variables at each time interval are presented in Table 4.

Complications

There were no nerve, vascular, or tendon injuries using either technique. No procedures were converted to the OCTR. Bleeding was minimal. There were no infections. No hands had persistent or recurrent symptoms or signs of complex regional pain syndrome.

DISCUSSION

The PCTR follows the concept of the mini-OCTR: protection of the critical structures under ultrasonography, and it was made less invasive by shortening the incision to 4 mm, placing it out of the critical pillar rectangle,[9] and minimizing dissection. It provided neurologic improvement equal to the mini-OCTR and quicker wound healing, less postoperative morbidity, and earlier functional recovery and achievement of satisfaction than the mini-OCTR. Our previous comparison of the mini-OCTR and OCTR showed similar advantages in the former,[3] and this study indicates that the PCTR has strengthened this trend.

According to the literature, recovery ensues, regardless of the specific technique,[1,2] and this was also the case with ours. However, our patients' improvement seemed slow compared to other series' outcomes. In our series, the percentage of symptom-free hands was less than 30% at 3 months and more than 80% at 2 years. The mean static 2-point discrimination was greater than 10 mm before surgery, and it improved to 6 to 8 mm at 3 months and 5 to 6 mm at 2 years. The mean Semmes-Weinstein monofilament grade showed loss of protective sensation before surgery, which improved to diminished protective sensation at 3 months and diminished light touch at 2 years (Table 1). The mean APB power was <3 before surgery, and reached 4 at 1 year (Table 2). Previous studies[1,2] reported complete symptom relief in 64% to 92% of the patients at 3 months, and 93% to 100% at 6 months. The mean static 2-point discrimination was 6 to 8 mm before surgery and 5 to 6 mm at 3 months. The mean Semmes-Weinstein monofilament grade was diminished protective sensation before surgery, which improved to diminished light touch at 3 months. The mean APB power was >4 before and after surgery. We think that our patients' slower recovery was due to more severe CTS, as shown by the greater 2-point discrimination and Semmes-Weinstein monofilament grade and less APB power before surgery.

The PCTR protects all vital structures. Release along the safe line protects the median nerve and ulnar neurovascular bundle. The position of the latter should be confirmed, because it often exists radial to the hook of hamate.[11,12] The SPA is protected because the device is passed proximal to it. The flexor tendons are mildly retracted by the holder and kept away from the blade. In addition, the device was made thin, minimizing pain and nerve compression.

We also took median nerve anomalies into account. On the basis of Lanz classification,[13] groups II (accessory branches at the distal carpal tunnel) and IV (accessory branches proximal to the tunnel) occur radial to the nerve and are not at risk because release is done ulnarly away from it. Most group I anomalies (variations in the course of the motor branch) are present radial or palmar to the nerve and are not at risk for the same reason. The exception is a branch bent ulnarly at the distal edge of the TCL.[8] This is associated with a

hypertrophic flexor pollicis brevis or palmaris brevis, which can be confirmed by ultrasonography. Unlike the previous report,[3] we now do not consider group III (high division of the nerve) a contraindication, as long as the safe zone is greater than 3 mm.

Although the PCTR minimized surgical trauma, it was still associated with some pillar pain and loss of strengths. Our previous comparison of the mini-OCTR and OCTR showed less pain and better grip and key-pinch strengths in the former,[3] and this comparison of the PCTR and mini-OCTR showed a similar trend. Combining these results and the patients' statement that the pain considerably limited their strengths, we think that the reduction of surgical trauma resulted in less pain and subsequently in better strengths. Although we did not investigate the origin of the pillar pain, we speculate that it is a consequence of transient inflammation, rather than neuromas, for the following reasons: (1) It usually improves in months as the scar softens and the reddish (inflammatory) appearance subsides, and (2) if pain is the result of neuromas from divided nerves, the pain is likely to be more permanent.

Because the carpal tunnel is not explored in the PCTR, we evaluate the following before surgery: (1) Local pathology, including bony abnormalities, space-occupying lesions, and tenosynovial thickening, is ruled out by plain radiographs and ultrasonography. Space-occupying lesions tend to be found in unilaterally afflicted patients.[14] Tenosynovial thickening often indicates inflammation, as in rheumatoid arthritis or infection.[15] (2) Because the device creates an approximately 3-mm-wide acoustic shadow, the safe zone should be wider than this at any level to confirm complete avoidance of the median nerve and ulnar neurovascular bundle.[7] The median nerve enlargement proximal or distal to compression and the ulnar neurovascular bundle radial to the hook of hamate[11,12] narrow the zone. (3) There should be no thick vessels along the path of the cutting device. We screen out the persistent median artery, SPA existing close to the distal TCL, and other vessels by color Doppler imaging. Thick collateral vessels are often found in hands with an arteriovenous fistula for hemodialysis. (4) There should be no hypertrophic flexor pollicis brevis or palmaris brevis extending into the safe zone.[8] (5) Communication is ruled out electrophysiologically between the median nerve and the abductor digiti minimi[5] and between the ulnar nerve and digital nerve to the third web space,[6] because the former crosses and the latter exists close to the safe line. (6) The thickness of the TCL is ultrasonographically measured and should be less than 3 mm. Patients with gigantism sometimes have an extremely thick TCL. Because we designed the cutting device on the basis of the normal anatomy of the TCL,[16] the blade may be small for such patients. However, we have not had this problem with patients of other etiologies. Among these factors, a narrow safe zone constitutes the most frequent reason that the PCTR is contraindicated in our experience.

Although ultrasonography played a major role in this study, its use for carpal tunnel release is not yet an established method. Because it is examiner-dependent, involving a learning curve and interobserver variation in interpretation, the technique should be selected and performed by a surgeon experienced in ultrasonography, as was done in this study. We think that safety is ensured not only by proper performance of surgery but also by correct selection of the technique. Performing a different technique (eg, the PCTR in hands with a distal narrow safe zone) will not necessarily lead to poorer outcomes, as long as release is done without complications, because improvement would ensue regardless of the technique.[1,2] However, this would risk the critical structures.

There are technical tips: (1) The TCL might be deep in a thick hand. If this is the case, pressing the guide dorsally at the entry point will help insertion. (2) The guide should be inserted beneath the TCL from its distal edge. If this is properly done, the resistance upon insertion is minimal. If there is considerable resistance, the guide is likely to be through the TCL, proximal to its distal edge, which would result in distal incomplete release. (3) Release should be completed with a single pass of the device. When division of the proximal TCL is found to be incomplete, it can be divided by repeating the surgical steps (Figs. 1 and 2) without making additional incisions or adding other procedures. In our experience, however, this is time-consuming.

There are limitations to this study: (1) The patients were not randomized to the techniques. We initially attempted randomization. However, this was not possible, primarily because of the variation of the safe zone. Those initially assigned to the PCTR were often found to have a narrow safe zone distally, and the technique had to be converted to the mini-OCTR. Patients' refusal was another reason. Some of them, who had initially been allocated to the mini-OCTR, later wished to have the PCTR. Nevertheless, the preoperative demographic, clinical, and electrophysiologic data from both groups were comparable (Tables 1–4), probably because the study population was homogeneous. (2) No standardized instruments were used for the evaluation. This was because none were available that had been cross-culturally adjusted and authorized to use in our country

during this study period. (3) The sample size was small. To detect a significant difference, the true difference should be greater than .4 times the standard deviation, a conventionally used value,[10] although we confirmed the advantages of the PCTR in the early postoperative period. (4) To test the aforementioned hypothesis, the PCTR was compared with the ultrasonographically assisted mini-OCTR, not with other techniques without ultrasonography, especially the standard mini-OCTR (incision, 1.5–2.0 cm) recently performed by many hand surgeons. However, we think that our mini-OCTR is equivalent to the standard mini-OCTR with respect to the extent of surgical trauma, except for using a slightly shorter incision (1.0–1.5 cm). Therefore, the data on pain, grip and key-pinch strengths, scar sensitivity, and satisfaction scores, as well as neurologic findings, would be similar to those from the standard mini-OCTR.

In summary, the PCTR provided the same neurologic recovery as did the mini-OCTR. It led to quicker wound healing, less postoperative morbidity, and earlier functional return and achievement of satisfaction.

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臨床経験

プロポフォール単剤による救急患者における迅速気管挿管

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プロポフォール単剤による救急患者における迅速気管挿管

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【要旨】 方法：プロポフォール単剤による救急患者における迅速気管挿管の状態を，下顎の弛緩，喉頭鏡に対する抵抗，声帯の位置，声帯の動き，チューブ挿入時の刺激による四肢および横隔膜の動きで評価した。結果：22例全例がプロポフォール単剤で気管挿管できた。下顎の弛緩は21例で良好で，喉頭鏡に対する抵抗もなかった。声帯は13例（59%）が開口状態で，動きもなかった。チューブ挿入時の刺激に対して11例(50%)で四肢の動きはなく，10例（45%）で横隔膜の動きもなかった。チューブ挿入時の刺激に対し2例（10%）で四肢は激しく動き，2例（10%）で横隔膜が激しく動いた。うち1例は四肢・横隔膜ともに激しく動いた。気管挿管時の総合評価は，excellent 10例（45%），good 9例（41%），poor 3例（14%）であった。まとめ：プロポフォール単剤で，救急患者における迅速気管挿管可能な状態が作成できる。

索引用語：プロポフォール，迅速気管挿管，鎮静薬

はじめに

迅速気管挿管（RSI；rapid sequence intubation，以下RSIと略す）における薬剤の選択は，施設・医師により使用する薬剤が異なり，標準化が困難な領域といえる。ガイドラインやマニュアルにおいても使用される薬剤の紹介や，いくつかの方法が紹介されるに過ぎない[1,2]。プロポフォールは速効性かつ短時間作働性の鎮静薬で，制吐作用，咽喉頭反射抑制作用，脳保護作用を有し，救急患者に使用するにあたり多くの利点をもつ[3-7]。救急患者においてプロポフォール単剤で迅速気管挿管（RSI；rapid sequence intubation，以下RSIと略す）し，気管挿管時の状態を評価したので報告する。

目　的

プロポフォール単剤での救急患者におけるRSIを評価する。

対象および方法

2001年（平成13年）1月1日から5月31日までに当救命救急センターに自発呼吸を有した状態で来院し，初期治療室で気管挿管が必要となった症例を対象に，気管挿管時の状態を評価した。気管挿管の適応は，意識障害患者（Glasgow coma scale 8点以下で考慮），ショック患者，全身麻酔による処置を必要とする患者，人工呼吸管理を必要とする患者などである。薬物中毒症例，挿管前に抗痙攣薬や筋弛緩薬の投与を受けた例，四肢の動きがない脊髄損傷

Emergency Rapid Sequence Intubation Using Propofol Alone

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症例は対象から除外した。血圧測定後に末梢静脈路からプロポフォール1-2mg/kg（体重が確認できない場合には主治医が推定）をボーラス投与し，20秒後に睫毛反射の消失と開口が容易なのを確認し気管挿管した。睫毛反射の消失や開口ができない場合，主治医（日本救急医学会指導医2名，日本救急医学会専門医3名）の判断で適宜追加投与し，睫毛反射の消失と開口が可能なのを確認し気管挿管した。気管挿管が30秒以内にできない場合，1度に限りやり直した。やり直し時のプロポフォールの追加投与も，睫毛反射と開口を確認しながら主治医の判断で行った。プロポフォールにより得られる挿管時の状態を，6つの項目（下顎の弛緩，喉頭鏡に対する抵抗，声帯の位置，声帯の動き，チューブ挿入時の刺激に対する四肢および横隔膜の動き）について，最良，良，不可の3段階で評価した[8]（表1）。主治医に加え，各科（外科，麻酔，循環器，整形）からの出向専門医4名からなる担当医と，研修医5名が加わり，チームで気管挿管の状態を評価した。なお声帯の動きを認めた場合には，声帯開口時に気管挿管した。挿管チューブの固定終了後，再度血圧を測定した。6つの項目すべてで最良の場合に，総合評価としてexcellentとした。1項目でも不可がある場合総合評価としてpoorと定義し，ほかはgoodとした。

結　果

5ヶ月間に当救命救急センターに自発呼吸を有した状態で来院し，気管挿管を要した患者は54例(外傷24例，薬物中毒7例，脳血管障害15例，心不全2例，その他6例）であった。薬物中毒7例，挿管前に抗痙攣薬や筋弛緩薬などの投与を受けた15例(外傷4例，脳血管障害7例，その他4例)，四肢の動きがない脊髄損傷2例は除外した。また全身状態が不安定で，挿管時の観察・記録ができなかった8例（外傷7例，心不全1例）を除き，結果として22例（外傷11例，脳血管障害8例，心不全2例，敗血症1例）の気管挿管時の状態を評価した。外傷9例，脳血管障害8例は意識障害で，外傷2例，心不全2例，敗血症1例は人工呼吸管理が必要と判断され気管挿管の適応となった。

プロポフォールを127 ± 55mg使用し，プロポフォールのみで全例気管挿管できた。チューブの挿入は，研修医5名で13例，各科出向専門医4名で6例，日本救急医学会専門医2名で3例行った。喉頭観察中の嘔吐はなかった。

評価の結果を表2に示す。下顎の弛緩が不良の症例はなく，22例中21例で下顎の弛緩は良好であった。また喉頭鏡に対する抵抗も21例でなかった。

声帯は22例中13例（59%）で開口状態であり，動きも静止していた。声帯が閉鎖していた症例はなかったが，9例は半閉鎖状態であった。9例で声帯の動きを認めた。

22例中11例（50%）でチューブ挿入時の刺激に対して四肢の動きはなく，横隔膜の動きも10例（45%）でなかった。チューブ挿入時の刺激に対し2例（10%）で四肢は激しく動き，2例（10%）で横隔膜は激しく動いた。うち1例は四肢・横隔膜ともに激しく動いた。

気管挿管時の総合評価は，excellent 10例（45%），good 9例（41%），poor 3例（14%）であった。

プロポフォール投与前の収縮期血圧は149 ± 44mmHgであったが，挿管後には121 ± 41mmHgに低下した。

考　察

プロポフォール単剤で救急患者22例全例に気管挿管できた。気管挿管時の総合評価は，excellent 10例（45%），good 9例（41%），poor 3例（14%）3例で，理想的な気管挿管の状態とはいえないが，プロポフォール単剤で，救急患者におけるRSI可能な状態が作成できた。

一般的にRSIでは鎮静薬に加え，鎮痛薬，筋弛緩薬が用いられる。患者に応じて薬剤を選択するが，一般的に鎮静薬にはthiopental, midazolamが，鎮痛薬にはfentanylが，筋弛緩剤にはSCC(succinylcholine)，VB（vecuronium bromide）などが用いられる。使用する薬剤は複数となり，注意事項も多い。鎮痛剤であるfentanylは，循環に大きな影響を与えないものの，筋固縮などの副作用をもち，また鎮静薬の多くは循環抑制作用をもつ。筋弛緩薬は，短時間での作用の発現と持続が望ましいものの，これに合致

表1　気管挿管時の状態評価の基準

	評価基準		
	最良	良	不可
下顎の弛緩	良好な弛緩	不完全な弛緩	弛緩不良
喉頭鏡に対する抵抗	なし	少し抵抗	強い抵抗
声帯の位置	開口	半閉鎖	閉鎖
声帯の動き	なし	動いている	閉鎖中
四肢の動き	なし	1・2回の小さな動き	激しい動き
横隔膜の動き	なし	1・2回の小さな動き	激しい動き

表2　気管挿管時の状態評価の結果

	評価基準		
	最良	良	不可
下顎の弛緩	21（95%）	1（ 5%）	0（ 0%）
喉頭鏡に対する抵抗	21（95%）	1（ 5%）	0（ 0%）
声帯の位置	13（59%）	9（41%）	0（ 0%）
声帯の動き	13（59%）	9（41%）	0（ 0%）
四肢の動き	11（50%）	9（40%）	2（10%）
横隔膜の動き	10（45%）	10（45%）	2（10%）

するSCCは，副作用として高カリウム血症，頭蓋内圧上昇，眼圧上昇，胃内圧上昇，投与後の筋肉痛などをもつ。VBは長時間作用する筋弛緩剤で，気管挿管困難時に大きな問題となる。リドカインやアトロピンを前投与する施設もあり，標準化が困難な領域といえる。

近年，筋弛緩薬を使用しない気管挿管が注目されている[9]。麻酔時間の短縮で注目されているが，筋弛緩薬を使用しないことでRSIの2つの大きなリスク（①full stomachの可能性と続発する嘔吐・誤嚥の危険性，②薬剤投与後に認識される予想外の挿管困難）が軽減可能となる。この2つのリスクはとくに救急患者で問題となるが，筋弛緩薬を使用しなければ，胃・食道接合部のflap valve機能が残り嘔吐・誤嚥のリスクが軽減され，予想外の挿管困難時にも自発呼吸があることで対処可能となる。筋弛緩薬を使用すると腹膜刺激症状や，意識レベルの判定が困難になり，時に腹壁筋の弛緩により腹腔内出血が増大する危険性もある。救急患者では数少ない情報で気管挿管しなければならず，筋弛緩薬使用は避けた方が好ましいといえる。また筋弛緩薬は毒薬に分類され麻薬とともに施錠管理が必要である。救急の初期治療室は，絶えず医療従事者が常駐しているわけではなく，また患者・家族の出入りを考慮すると，毒薬・麻薬の保管場所として適切な場所とはいえない。

プロポフォールは劇薬で施錠管理の必要はない。秒単位の急速な効果発現と分単位の効果消失が特徴で，挿管困難時には短時間で挿管前の状態に戻すことができる[3,4]。制吐作用と咽喉頭反射の抑制作用を有し，筋弛緩作用もない[5,6]。したがってプロポフォール単剤によるRSIは，full stomach，挿管困難の2つの大きなリスクを最小限にできる。脳代謝を抑制し，脳保護作用も有し，頭部外傷や脳血管障害患者にも有用である[7]。意識の回復が速やかで，意識レベルの確認が必要な頭部外傷・脳血管障害，中毒患者の鎮静に適している。ただ循環抑制作用があり，血圧低下をきたすため，とくに心不全状態のときは用量を少なく，ゆっくり投与することが必要であろう。またショックをきたしている患者への投与は慎重にするべきである。血管痛を訴える患者もいる。

筋弛緩薬を使用しない気管挿管の報告の多くは，5分前にMidazolam 0.03mg/kgを静脈内投与後，

さらにプロポフォール2mg/kgを加えたり，90秒前にremifentanil2μg/kgやalfentanil20μg/kgを静脈内投与後さらにプロポフォール2mg/kgを加えたりしている[9]。気管壁刺激性低下を目的としたlidocaine1.5mg/kgを前投与する報告もある。これらの薬剤の使用により，理想的な気管挿管時の状態を作成可能なため，プロポフォール単剤での気管挿管を評価した報告はきわめて少ない。刻一刻を争う救急患者でのRSIでは，あらかじめ薬剤を投与することや，さまざまな薬剤を準備することは困難な場合が多い。麻薬や毒薬など施錠管理が難しい初期治療室の特徴も考慮すると，プロポフォール単剤でのRSIは，救急患者において容認できると判断している。意識下挿管（awake intubation）は，胃・食道接合部のflap valve機能や咽頭反射が残存し，誤嚥の可能性が低く救急患者に対する気管挿管として選択枝の1つとなるが，患者の協力が必要で手技に熟練を要する。当センターでは，この研究結果に基づき，その後も年間100－200例のRSIの大部分をプロポフォール単剤で行い，RSIの標準化に成功した。挿管困難から外科的気道確保となった例や，一時的血圧低下をきたした例はあるが，ほかに大きな問題となった例はない。

まとめ

四肢や横隔膜の動きが激しい患者は存在したが，喉頭観察も容易で，観察中の嘔吐もなく，プロポフォール単剤で，救急患者におけるRSI可能な状態が作成できる。

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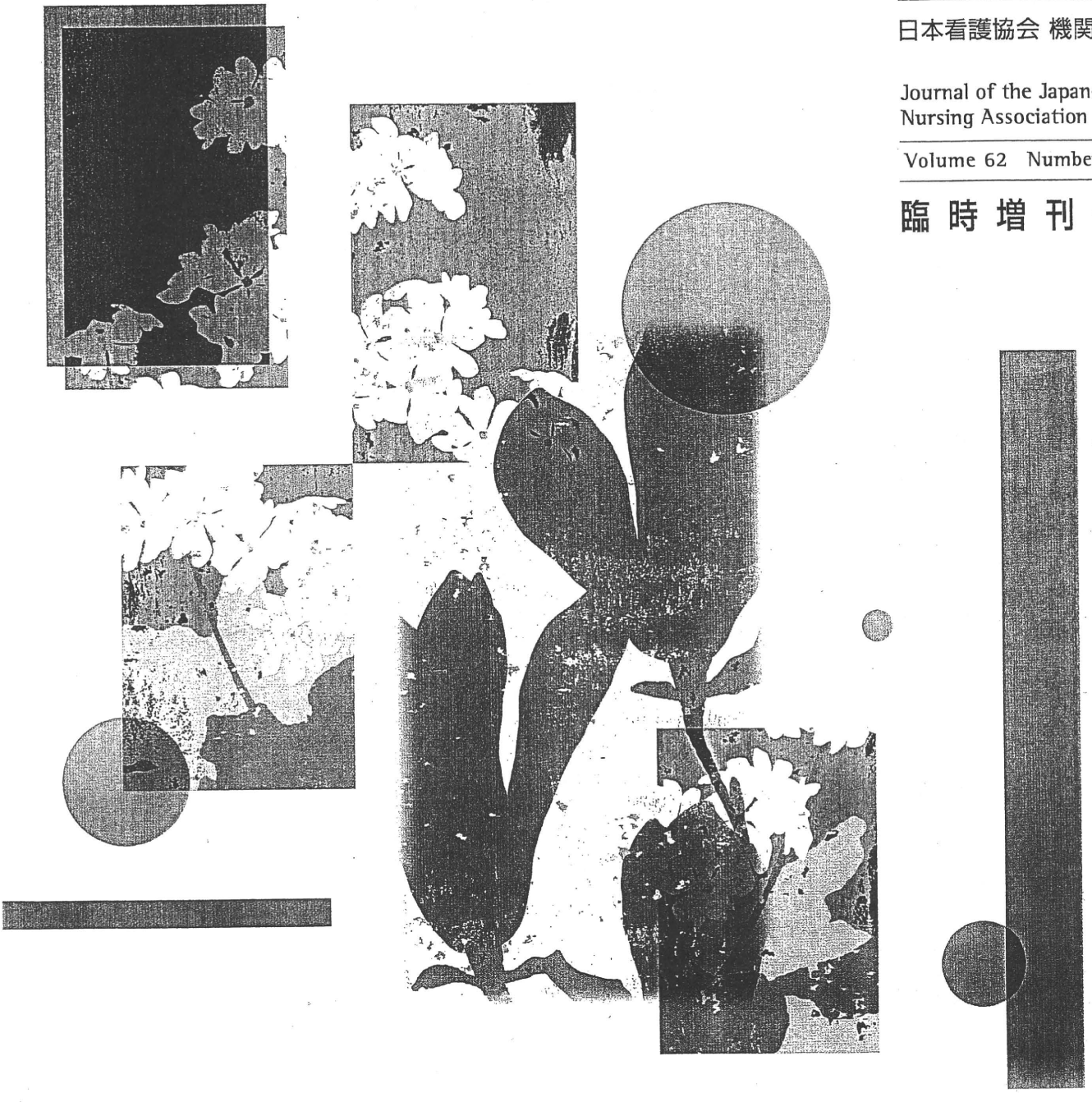

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