の先はシュリーレン画像上ではビームが消
失しているのが観察されている。

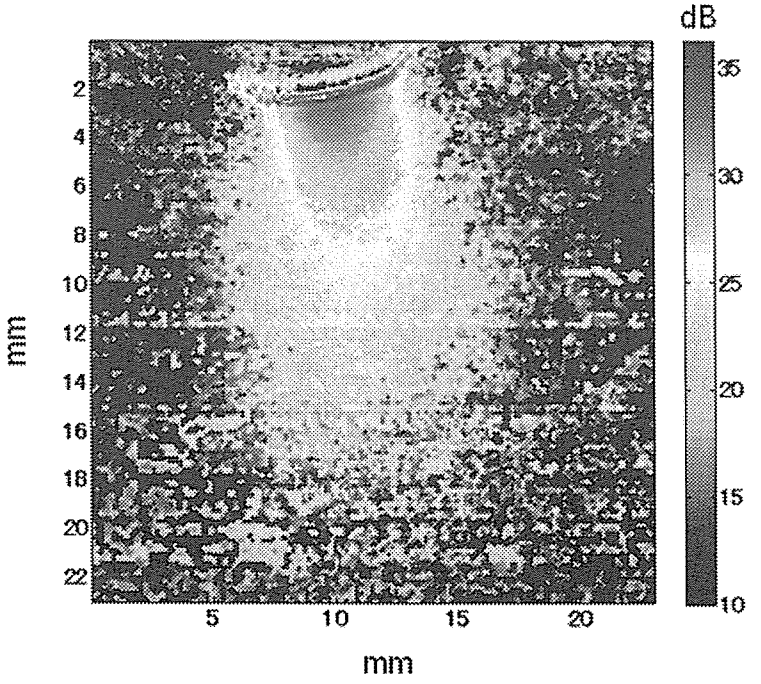

図8　頭蓋骨無の場合のシュリーレン画像

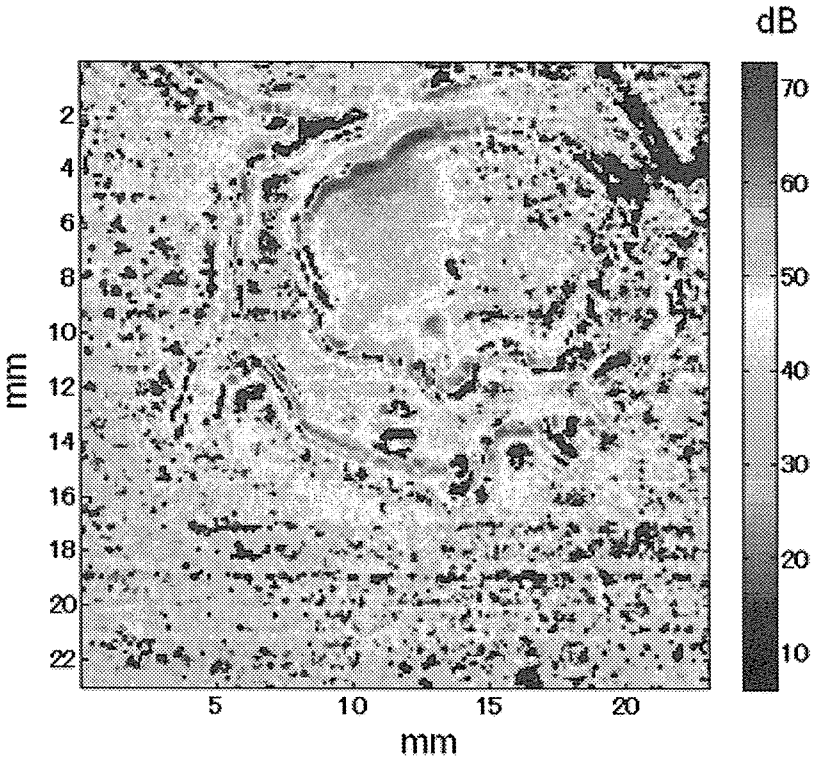

図9　頭蓋骨有(トランスデューサから 0mm)
の場合のシュリーレン画像

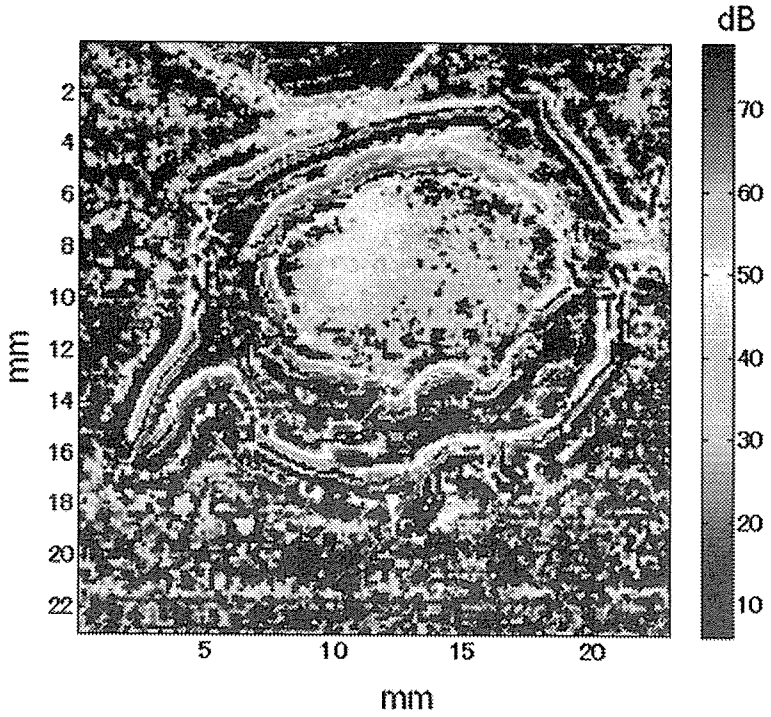

図10　頭蓋骨有(トランスデューサから 3mm)
の場合のシュリーレン画像

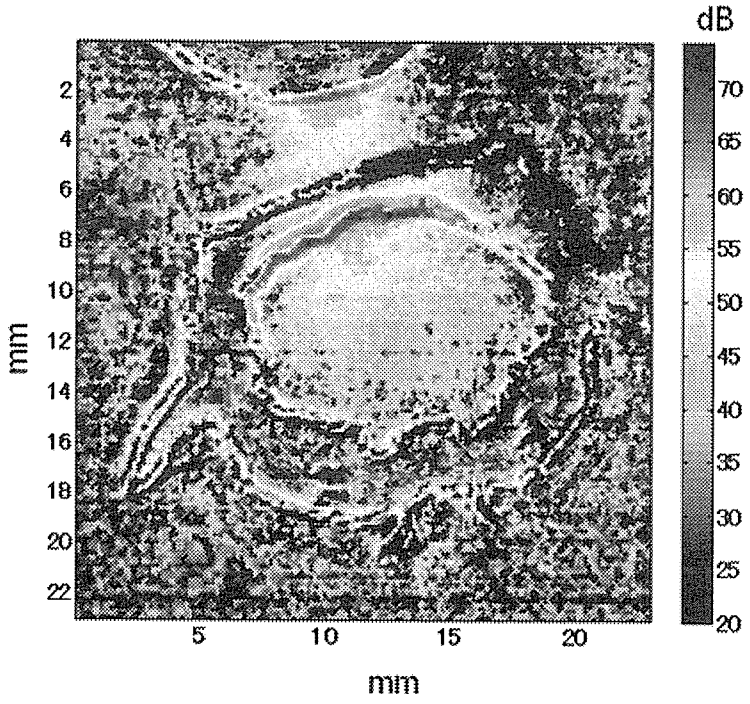

図11　頭蓋骨有(トランスデューサから 5mm)
の場合のシュリーレン画像

(1)－2　ハイドロフォンによる音場の測定結果

図12から18にハイドロフォンでの測定結果を示す。上から順に、頭蓋骨無し、ハイドロフォンとトランスデューサ間の距離が2mm、5mm、10mm。次に頭蓋骨有りで、トランスデューサと頭蓋骨間の距離が0mmで、ハイドロフォンとトランスデューサ間の距離が5mm、10mm。最後に、トランスデューサと頭蓋骨間の距離が3mmで、ハイドロフォンとトランスデューサ間の距離が8mm、13mm。

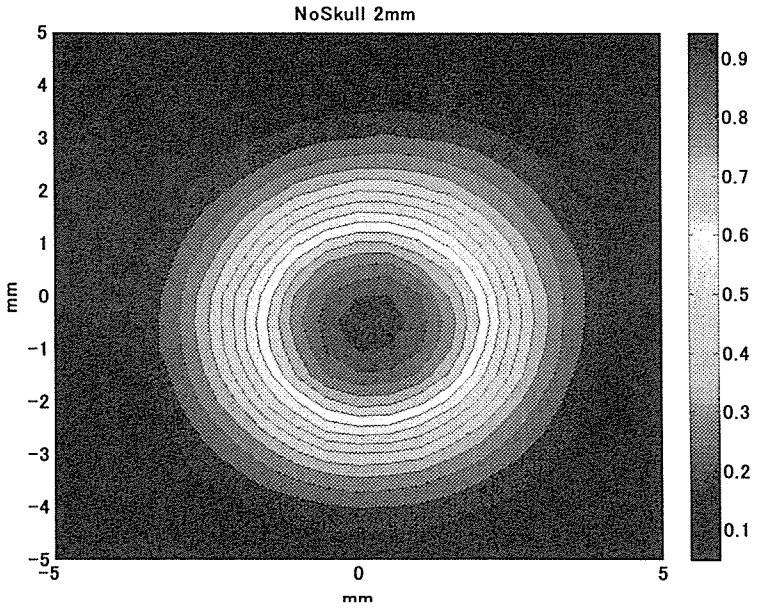

図12　頭蓋骨無の場合のハイドロフォン測定結果
（トランスデューサ表面から 2mm）

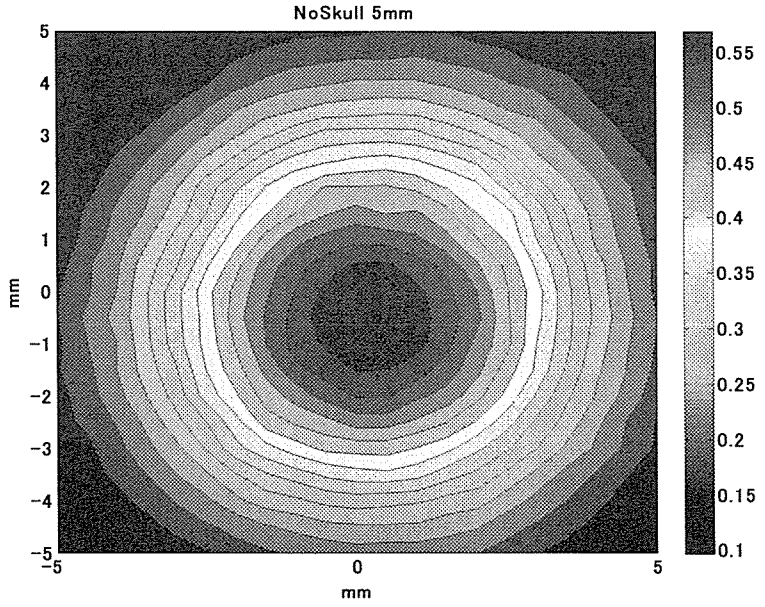

図13　頭蓋骨無の場合のハイドロフォン測定結果
（トランスデューサ表面から 5mm）

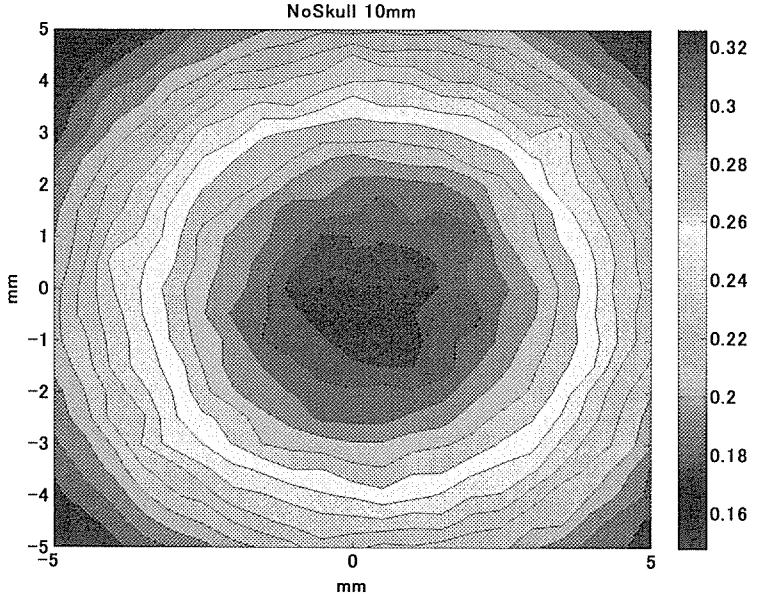

図14　頭蓋骨無の場合のハイドロフォン測定結果
（トランスデューサ表面から 10mm）

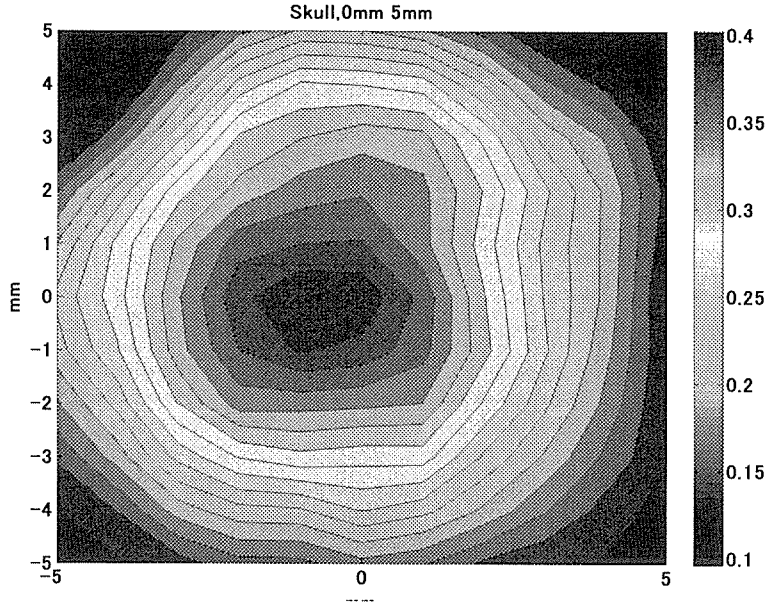

図15　頭蓋骨有の場合のハイドロフォン測定結果
（頭蓋骨とトランスデューサ間 0mm、
トランスデューサ表面から 5mm）

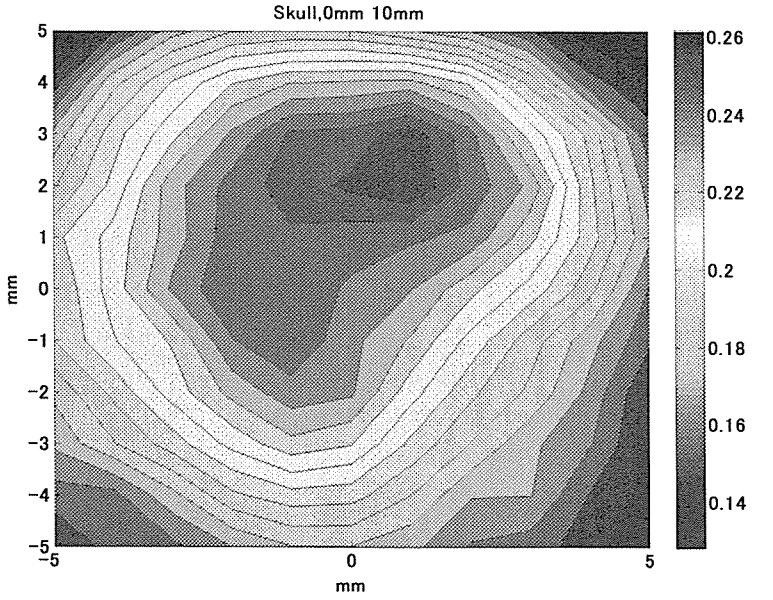

図16　頭蓋骨有の場合のハイドロフォン測定結果
（頭蓋骨とトランスデューサ間 0mm、
トランスデューサ表面から 10mm）

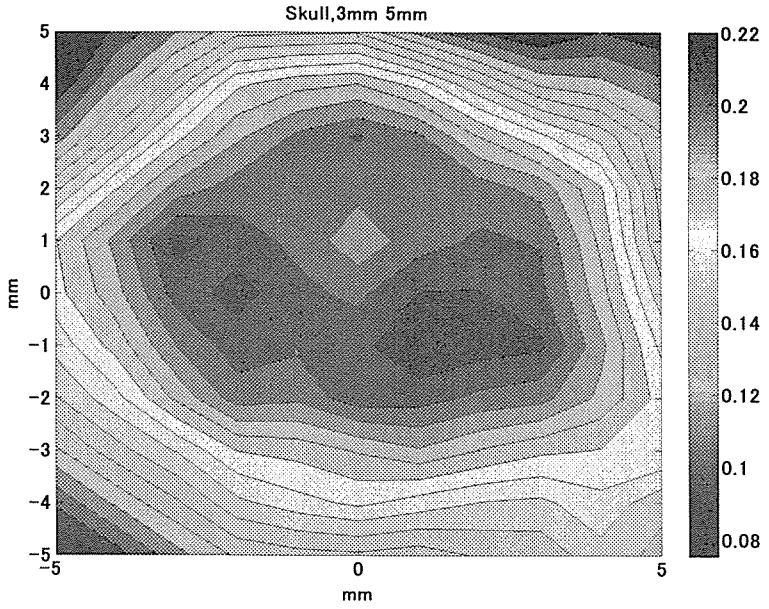

図17　頭蓋骨有の場合のハイドロフォン測定結果
（頭蓋骨とトランスデューサ間 3mm、
トランスデューサ表面から 8mm）

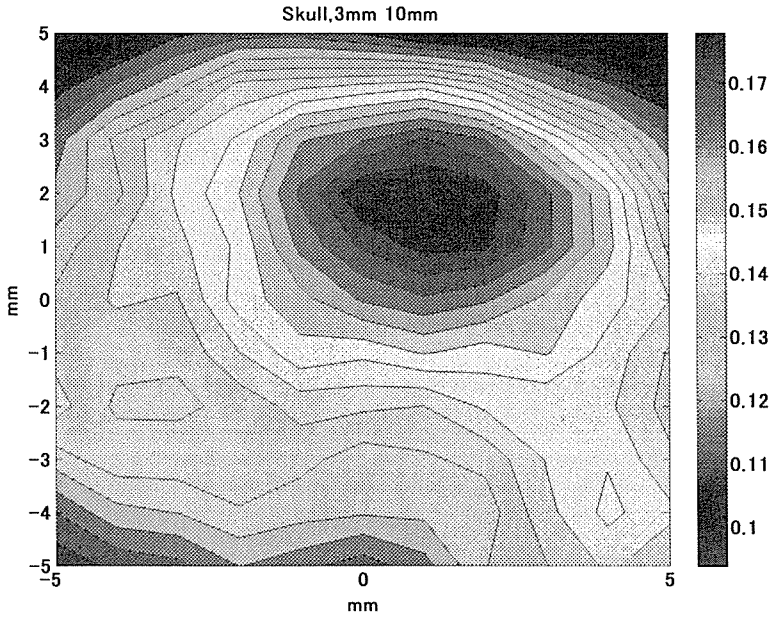

図18　頭蓋骨有の場合のハイドロフォン測定結果
（頭蓋骨とトランスデューサ間 3mm、
トランスデューサ表面から 13mm）

表1に、各測定条件における、音圧の最大値を示す。頭蓋骨が無くてもトランスデューサから10mm（ラット頭蓋骨の反対側）において、音圧が 1/3、頭蓋骨を介した場合には 1/5（エネルギーでは 1/25）まで下がっていることが分かった。

次に、ハイドロフォンを面内でスキャンした場合でなく、深さ方向にスキャンした結果を示す。図19は、500kHz、300kHz それぞれにおける測定結果で、グラフは頭蓋骨無し（青）及び頭蓋骨とトランスデューサ間の距離を変えた測定結果を示す。それぞれ、図中に矢印で示す波長の半分の間隔の周期が見える。図20は波長の半分の間隔の周期の効果を無くすために深さ方向に平均加算を行った結果である。

表1　各測定条件におけるハイドロフォン測定値

	頭蓋骨無し			頭蓋骨/トランスデューサ間0mm		頭蓋骨/トランスデューサ間3mm	
ﾊｲﾄﾞﾛﾌｫﾝ/ﾄﾗﾝｽﾃﾞｭｰｻ間距離 *	2mm	5mm	10mm	5mm	10mm	5mm	10mm
ピーク音圧（頭蓋無2mmで規格化）	1	0.56	0.33	0.4	0.26	0.22	0.18

＊頭蓋が有る場合は、頭蓋ﾄﾗﾝｽﾃﾞｭｰｻ間の距離

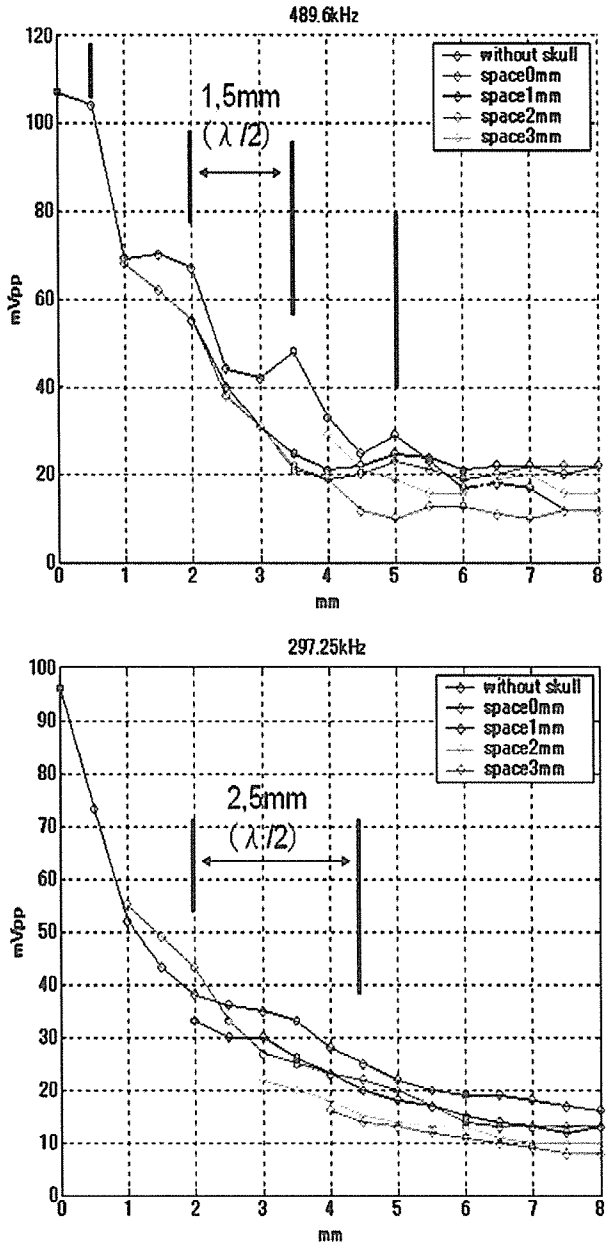

図19　500kHz（上）と300kHz（下）における ハイドロフォン測定値

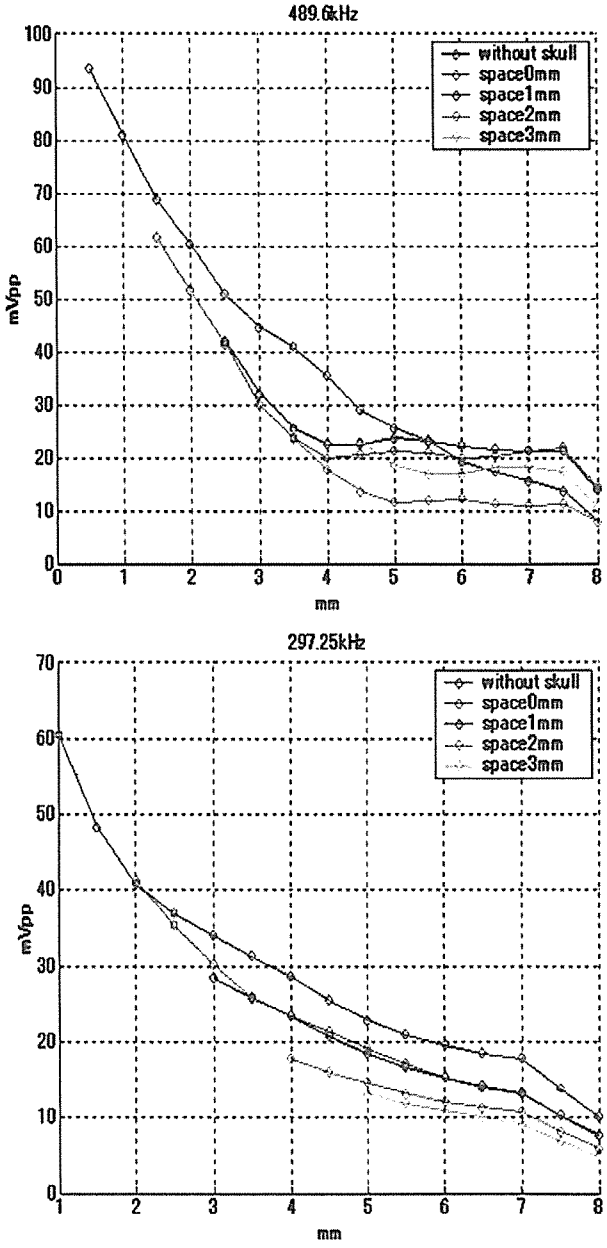

図20　500kHz（上）と300kHz（下）における ハイドロフォン測定値 （深さ方向へのフィルタ処理後）

（2）超音波ビームに与える頭蓋骨の影響に関する検討

図19から21に頭蓋骨を介した場合と介さない場合のワイヤターゲットの超音波画像を示す。

また、図22には、頭蓋骨を介したワイヤからの反射エコーの方位方向における強度分布をしめす。超音波断層像から、頭蓋骨を介して、点応答関数が方位方向に伸びていることが確認出来る。また、図22から、反射エコーの強度が大きく低減していることがわかる。

ビーム幅は方位方向に約 2 倍、感度は低下の著しいところにおいては、1000 分の 1 になっていることが分かった。

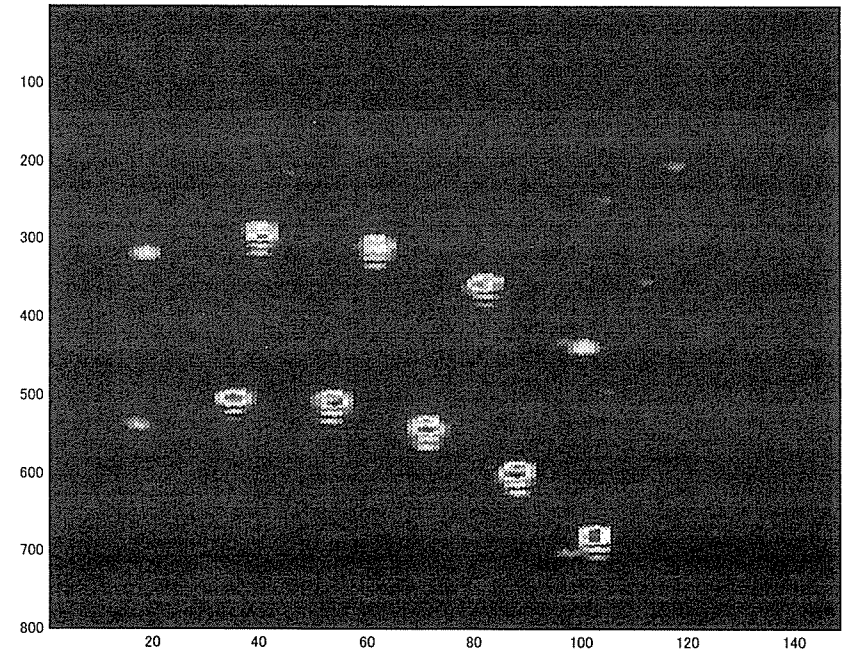

図21　頭蓋骨無しでのワイヤの超音波画像

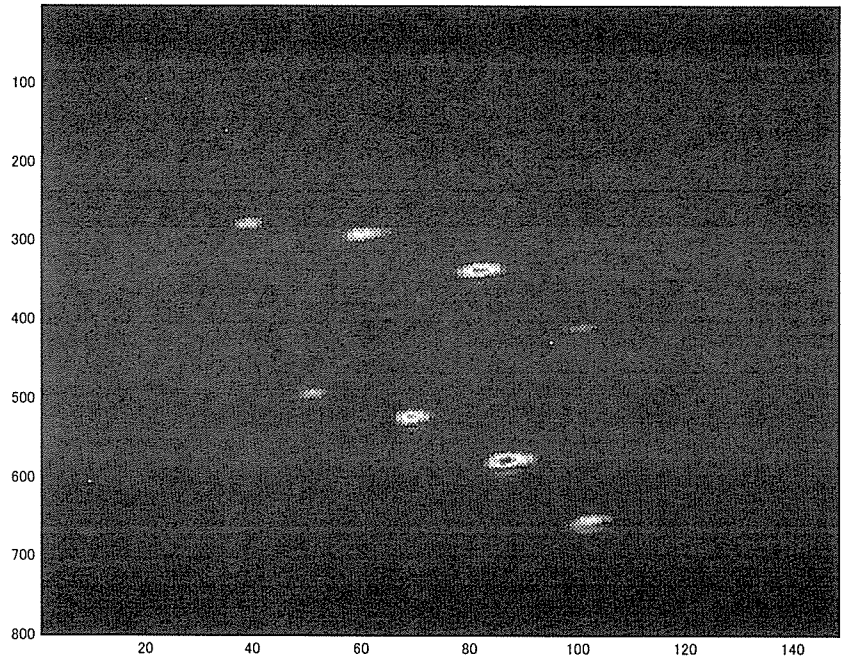

図22　頭蓋骨有りでのワイヤの超音波画像

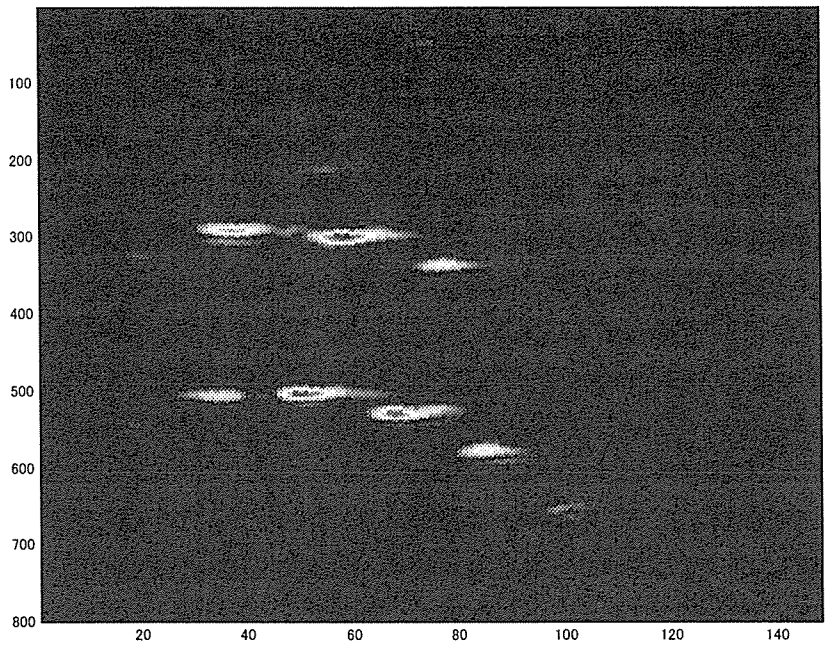

図23　頭蓋骨無しでのワイヤの超音波画像

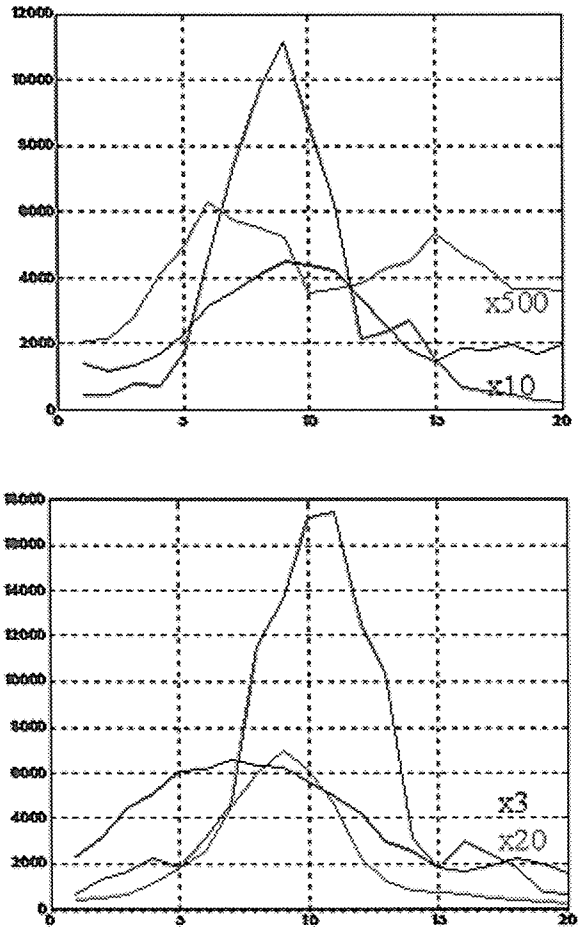

図24　ワイヤからの反射エコーの方位方向強度分布

D.　考察

(1)ラット頭蓋内音場の定性的及び定量的な測定

(1)－1　シュリーレン法による音場の測定結果

図8から11に示されるようにシュリーレン法の測定では、5mm程度超音波ビームが進んだあと、超音波ビームは消失しているように見える。シュリーレン法では、音が減衰した場合以外にも、波面と光軸が平行で無い場合に超音波ビームが画像化できない。近距離音場から、遠距離音場の遷移点は口径D,波長λに対して と表されるので、今回の測定の 500 kHz では、波長が3mm、口径幅が5mmなので、8mmで近距離音場から遠距離音場へ変化する。遠距離音場においては、Fraunhofer 回折が支配的な音場となる。図23に示すように、①の光軸と波面が平行な領域では、シュリーレン法によって超音波ビームが画像化されるが、②の領域では超音波ビームが画像化されない。今回の図8から11に示されるシュリーレン像においても、トランスデューサから5mm程度進んだ後、減衰している可能性と、回折によって広がっている可能性が両方あり、結論をえるには、

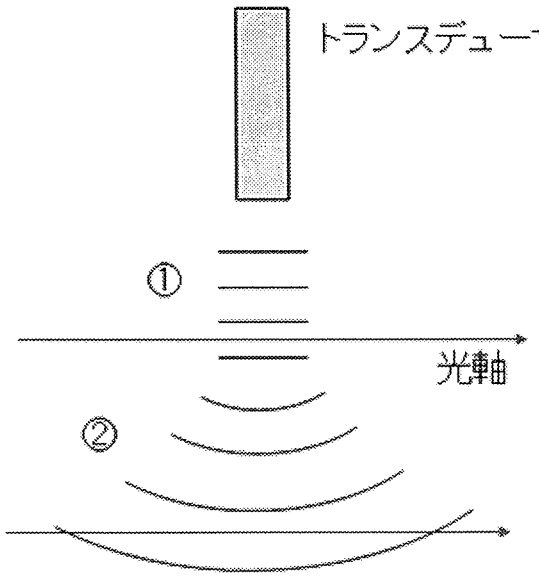

図24　フレネル解析とフラウンホーファー回析

ハイドロフォンによる定量的な測定結果を見る必要がある。

(1)－2　ハイドロフォンによる音場の測定結果

今回のハイドロフォンの測定により、トランスデューサ面から5mm程度離れるとビームが広がり始め、ラット頭蓋骨の反対側の辺りでは、音圧の振幅が 1/3 から 1/5 まで減少することが明らかになった。この結果は図19,20の結果ともほぼ一致する。図19の深さ方向に音圧が上下するのはトランスデューサとハイドロフォンの間の定在波の影響である。図19、20での、振幅の低下の程度がハイドロフォンを面内でスキャンした場合に比べ、多少小さいのは、深さ方向にスキャンした場合、ビームの中心から多少ずれる場合があるためである。なおこれらの測定で、ラットの頭蓋骨を透過するときの、超音波の減衰の効果は大きくなかった。

人の頭蓋骨に適用する場合においては、限られた音響窓である、こめかみを最大限に利用するために、2cm四方程度の口径を持ったトランスデューサを用いることが望ましい。実際、ドイツでの臨床例においては、300kHz、口径幅 30mm のトランスデューサ4つを用いている。300kHz、口径幅 30mm では、から計算される、近距離音場から遠距離音場への遷移点は 18cm となる。500kHz、口径幅 20mm の場合の人頭蓋骨内の超音波ビームの例を図26に示す。

この場合、超音波ビームは、頭蓋の反対側で反射してもなお、回折で広がらず、まっすぐ進んでいる様子が観察される。

一方、ラットでの動物実験系においては、人用のトランスデューサをそのまま適用することは難しい。ラットの頭蓋骨の大きさより、トランスデューサの方が大きくなってしまうからである。トランスデューサの大きさを縮小した分、周波数を上げることが出来れば、超音

波ビームとしては人の場合と相似なビームを作ることは出来る。しかし、この場合、Mechanical Index と Thermal Index ともに、周波数依存性があるため、周波数を変えてしまうと、適正な超音波の生体作用を検討したことにならなくなってしまう。

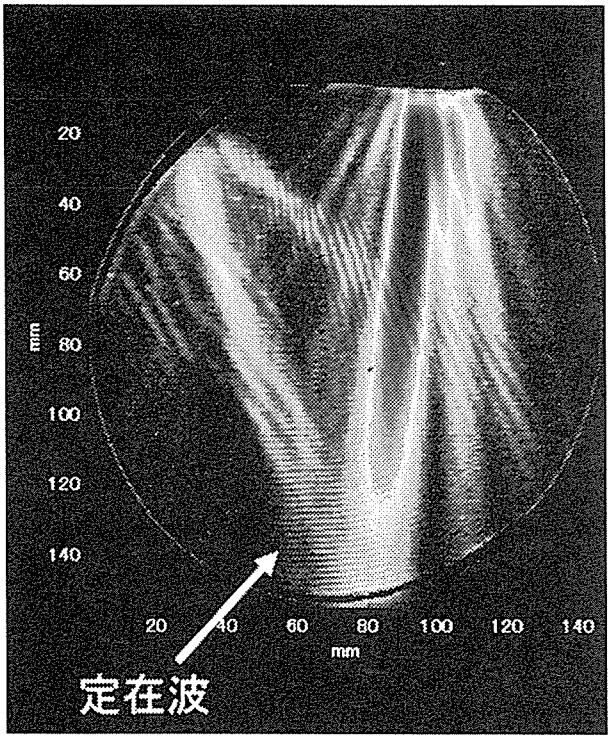

図26 人頭蓋骨内での 500kHz の超音波ビームのシュリーレン像

(2)超音波ビームに与える頭蓋骨の影響に関する検討

老齢の患者においては、超音波ドップラ像の感度が低く、超音波血栓溶解治療モニタリングが困難な場合がある。今回、感度向上のための予備的な検討として、頭蓋骨を介した場合と介さなかった場合の、点応答関数の違いの実験的な検討を行った。その結果、ビームの広がりは二倍程度であったが、感度の低下は著しく、最大では 1/1000 まで低下している場合もあった。今回の測定域においては板間層など、超音波減衰の大きい領域を介していない。よって、屈折補正や、音速補正などの効果が期待出来る。今後適用増再生技術などを用いることによって、どの程度感度向上が可能であるか、検討を行う必要がある。

E. 結論

(1) ラット頭蓋内音場の定性的及び定量的な測定

今回の検討の結果から、口径幅を動物に合わせて縮小トランスデューサを用いた動物実験系においては、

1. 近距離音場から遠距離音場に遷移する、トランスデューサからの距離が変わり、フラウンホーファー回折によって距離の二乗に反比例して音圧が低減する領域が照射対象域に含まれていないか注意が必要である。この場合には、補正した音圧で超音波を照射する必要がある。
2. 頭蓋の反対側に超音波ビームが到達するときに、フラウンホーファー回折が支配的になっていると、反射域での定在波生成の効果が過少評価されてしまう危険性がある。

(2) 超音波ビームに与える頭蓋骨の影響に関する検討

人頭蓋骨を介した、2MHz の超音波の点応答関数を実験的に調べた結果、ビーム幅は二倍、感度は最大で 1/1000 まで低下した。

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7) Azuma T., Kawabata K., Umemura S., Ogihara M., Kubota J., Sasaki A. and Furuhata H.: Bubble Generation by Standing Wave in Water Surrounded by Cranium with Transcranial Ultrasonic Beam, Jpn J Appl Phys 44: 4625-4630 2005.

G. 研究発表

1. 論文発表

論文発表はなかった。

2. 学会発表

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2) T. Azuma, K. Sasaki, K. Kawabata and S. Umemura: Coagulation Monitoring with Tissue Expansion Detecion during High Intensity Focused Ultrasound Therapy, 6th International Society of Therapeutic Ultrasound 2006.

3) J. Kubota, T. Azuma, M. Ogihara, S. Umemura and H. Furuhata: Avoiding cavitation in irradiation of sub-MHz ultrasound for thrombolysis, 6th International Society of Therapeutic Ultrasound 2006.

H. 知的財産権の出願・登録状況

1. 特許取得

特許申請及び予定はなかった。

2. 実用新案登録

登録申請及び予定はなかった。

3. その他

特記事項はなかった。

Ⅲ. 研究成果の刊行に関する一覧表

雑誌

発表者氏名	論文タイトル名	雑誌名	巻号	ページ	出版年
三村秀毅，井上聖啓，古幡博	脳梗塞における頭蓋外内頸動脈と中大脳動脈の超音波による循環動態評価-Pulsatility Index の比較を中心に-	Neulosonology			Accept
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Minematsu K.	Recent advance in acute stroke management.	International Congress Series	1290	25-29	2006
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Ⅳ. 研究成果の刊行物・別刷

Alteplase at 0.6 mg/kg for Acute Ischemic Stroke Within 3 Hours of Onset

Japan Alteplase Clinical Trial (J-ACT)

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Background and Purpose—Based on previous studies comparing different recombinant tissue plasminogen activator (rt-PA) doses, we performed a clinical trial with 0.6 mg/kg, which is lower than the internationally approved dosage of 0.9 mg/kg, aiming to assess the efficacy and safety of alteplase in acute ischemic stroke for the Japanese.

Methods—Our prospective, multicenter, single-arm, open-label trial was designed with a target sample size of 100 patients. The primary end points were the proportion of patients with a modified Rankin Scale (mRS) score of 0 to 1 at 3 months and the incidence of symptomatic intracranial hemorrhage (sICH) within 36 hours. Thresholds for these end points were determined by calculating 90% CIs of weighted averages derived from published reports. The protocol was defined according to the National Institute of Neurological Disorders and Stroke (NINDS) rt-PA stroke study with slight modifications.

Results—Among the 103 patients enrolled, 38 had an mRS of 0 to 1 at 3 months; this proportion (36.9%) exceeded the predetermined threshold of 33.9%. sICH within 36 hours occurred in 6 patients; this incidence (5.8%) was lower than the threshold of 9.6%.

Conclusions—In patients receiving 0.6 mg/kg alteplase, the outcome and the incidence of sICH were comparable to published data for 0.9 mg/kg. These findings indicate that alteplase, when administered at 0.6 mg/kg to Japanese patients, might offer a clinical efficacy and safety that are compatible with data reported in North America and the European Union for a 0.9 mg/kg dose. (***Stroke*. 2006;37:1810-1815.**)

Key Words: stroke, acute ■ thrombolytic therapy ■ tissue plasminogen activator

The National Institute of Neurological Disorders and Stroke (NINDS) recombinant tissue plasminogen activator (rt-PA) stroke study[1] demonstrated that alteplase treatment within 3 hours of onset improved functional outcome. On that basis, alteplase has been approved and recommended for treating acute ischemic stroke in 40 countries. In Japan, the regimen has not yet been approved but is used clinically.[2] Although randomized controlled clinical trials of rt-PA (duteplase) in Japan have demonstrated that intravenous duteplase was beneficial for acute embolic stroke patients within 6 hours of onset,[3–5] development of duteplase was aborted because of the patent issue. A pressing need exists to demonstrate that alteplase within 3 hours of onset is beneficial in the Japanese population. However, because randomized controlled trials, in which the alteplase arm is compared with the placebo arm, are impracticable under such circumstances, the regimen should be tested with another study design.

To assess the efficacy and safety in the Japanese population, a prospective, single-arm, open-label study was conducted. Although the internationally recommended dosage is 0.9 mg/kg, a 0.6 mg/kg dose was selected based on previous data for rt-PA in Japan.[3–5] The primary outcome measures were the proportion of patients without functional deficits at 3 months and the incidence of symptomatic intracranial hemorrhage (ICH) within 36 hours. These outcomes were compared with the results of a systematic review and meta-analysis based on data from the literature.

Materials and Methods

The trial was conducted between April 2002 and September 2003 at 22 centers in Japan under good clinical practice regulations. The protocol was approved by each institutional review board. An independent review committee monitored the study for safety.

Received February 10, 2006; final revision received March 27, 2006; accepted April 24, 2006.

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Stroke is available at http://www.strokeaha.org

DOI: 10.1161/01.STR.0000227191.01792.e3

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were as in the NINDS study.[1] We also excluded patients with a National Institutes of Health Stroke Scale (NIHSS) score of ≤4 at baseline, computed tomography (CT) evidence of significant early ischemic change (affecting more than one third of the middle cerebral artery territory), a comatose state, or a modified Rankin Scale (mRS) score of ≥2 before stroke onset.

Rationale for Dose Selection

In Japan, 3 randomized double-blind trials[3–5] of duteplase, an rt-PA very similar to alteplase, have been conducted on embolic stroke patients within 6 hours of onset. After a pilot study,[3] 20 million international units (MIU) of duteplase proved to be superior to placebo based on the angiographical recanalization rate.[4] Twenty MIU did not differ from 30 MIU in either the recanalization rate or clinical improvement.[5] However, massive brain hematoma/hemorrhagic transformation occurred in 2 of 56 patients given 20 MIU and 9 of 65 patients given 30 MIU.[5] Therefore, we considered that the optimal test dose of alteplase for the Japanese population was 20 MIU per person or 0.33 MIU/kg at a mean body weight of 60 kg and selected 0.6 mg/kg for the present trial, which is equivalent to 0.33 MIU/kg, as the appropriate alteplase dose, instead of the 0.9 mg/kg in the NINDS trial. Details of the properties and other relevant data for duteplase and alteplase are given in the supplemental Appendix 2, available online at http://stroke.ahajournals.org.

Intervention and Evaluation

A single alteplase dose of 0.6 mg/kg (not exceeding 60 mg) was administered intravenously, with 10% given as a bolus, followed by continuous infusion of the remainder over 1 hour.

The NIHSS, mRS, and Barthel Index (BI) were evaluated at the same time points as in the NINDS study.[1] CT scans were repeated before treatment and at 24 hours, 7 to 10 days, and 3 months or at discharge.

Symptomatic ICH (sICH) was defined prospectively in the protocol, as CT evidence of new ICH with apparent neurological deterioration, which was defined as documented objective evidence of neurological decline or an increase of ≥4 points from the most recent NIHSS score. The protocol required CT scans and NIHSS evaluations whenever neurological deterioration was identified.

As in the NINDS study, use of antithrombotic agents was prohibited for 24 hours after onset, blood pressure was maintained at <180/105 mm Hg, and neurological symptoms were frequently monitored.

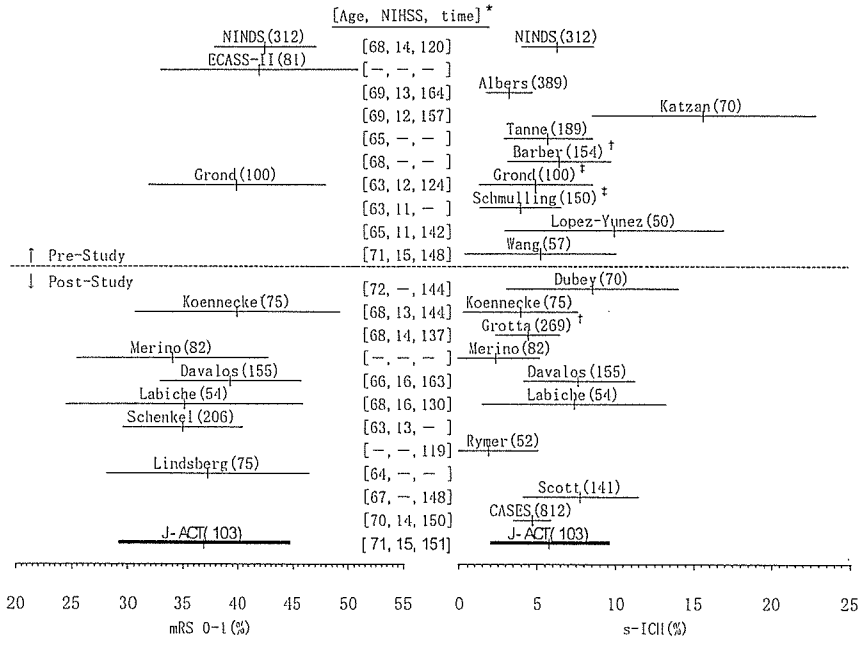
According to the prospective definition, CT evidence of hemorrhage was classified into 4 grades by the CT Film Reading Panel blinded to clinical information: (0) no hemorrhage; (1) hemorrhagic infarction without hematoma; (2) hematoma without shift of the midline structures; and (3) hematoma with shifts of the midline structures.

Primary End Points

The primary efficacy end point was the proportion of patients with favorable outcomes (mRS score of 0 to 1) at 3 months. The primary safety end point was the incidence of sICH within 36 hours after starting treatment. These primary end points were evaluated in comparison with a meta-analysis of published data on alteplase. To make response assessments in 100 patients, threshold values were predetermined as follows. We performed a Medline search in June 2001 with key words "ischemic or ischaemic/stroke/tissue plasminogen activator or alteplase," identifying all studies published after the NINDS report in which ≥50 patients were involved and the mRS data at 3 months[6,7] and incidence of sICH[8–14] were available. When reports contained overlapping patients, defined from the institutions and periods, those treating more patients were selected and assessed. Such overlapping occurred in reports from Cologne, Calgary, and Houston. As shown in the Figure, there is some possible heterogeneity (Katzan et al[11] and Lopez-Yunez et al[14]) among these studies visually. However, because we wished to embrace the actual medical conditions involving all of these studies, we used them for calculation of the combined statistics, weighted by study size, in the meta-analysis. These valid reports in combination with the NINDS study[1,15] revealed a weighted average proportion of mRS score of 0 to 1 at 3 months of 42.0%, with a 90% CI (95% for 1 tailed) in 100 patients of 33.9% to 50.1%; the lower confidence limit was used as the threshold. The weighted average incidence of sICH was 5.8%, with a 90% CI in 100 patients of 2.0% to 9.6%; the upper confidence limit was used as the threshold. The targets for our study were thus set at >33.9% as the proportion of patients with an mRS score of 0 to 1 at 3 months and <9.6% as the incidence of sICH within 36 hours. As other secondary analyses, including the BI at 3 months and NIHSS, comparisons with values from applicable published reports, such as the NINDS study, were undertaken.

Results

The baseline characteristics of the 103 patients enrolled were comparable to those in the NINDS study, except for body



Left, Proportion and 90% CIs of mRS score of 0 to 1 at 3 months. Right, Incidence and 90% CIs of sICH. Numbers of patients are indicated in parentheses. *[Age, NIHSS, time]=[mean age (years), baseline NIHSS median score, mean time (min) from onset to treatment]. †,‡Patients overlap in the same work of the respective trials. PreStudy means reports that were systematically reviewed in June 2001 for the purpose of prospective determination of the thresholds. PostStudy means reports that were newly picked up in the same manner as for the PreStudy at the end of this study in December 2003.

TABLE 1. Demographic and Baseline Characteristics of Patients

	J-ACT	NINDS Part 2	
	n=103	rt-PA n=168	Placebo n=165
Age (years)			
Mean±SD	70.9±9.8	69±12	66±13
Sex (female)	39 (37.9%)	(43%)	(42%)
Body weight (kg)			
Mean±SD	58.6±11.0	76±16	80±21
Baseline NIHSS score			
Median	15	14	15
Range	5–30	2–37	2–33
Stroke subtype			
Cardioembolic	80 (77.7%)	(45%)	(44%)
Atherothrombotic	12 (11.7%)	(39%)	(45%)
Lacunar	2 (1.9%)	(14%)	(9%)
Other/not differentiated	9 (8.7%)	(2%)	(3%)
Blood pressure			
Systolic (mm Hg)			
Mean±SD	151.0±19.0	153±22	152±21
Diastolic (mm Hg)			
Mean±SD	82.3±11.9	85±14	86±15
Blood glucose (mg/dL)			
Mean±SD	141.3±48.3	149±66	149±78
Previous stroke	21 (20.4%)	(12%)	(9%)
No pre-existing disability	85 (82.5%)	(95%)	(93%)
Previous use of antiplatelet drugs	30 (29.1%)	(40%)	(26%)
Concomitant disease			
Hypertension	55 (53.4%)	(67%)	(67%)
Diabetes	19 (18.4%)	(20%)	(20%)
Mean time from onset to treatment (min)	150.5	119.7*	

*In the NINDS study, the mean time from onset to treatment is reported as the combined value of all rt-PA, placebo, and parts 1 and 2.[16]

J-ACT indicates Japan Alteplase Clinical Trial.

weight and stroke subtypes (Table 1). The proportion of cardioembolic stroke was 45% in the NINDS trial but 78% in our trial. The mean time from onset to treatment was 150.5 minutes. The characteristics in the systematically reviewed studies shown in the Figure (see top part of Figure where PreStudy means reports that were systematically reviewed in June 2001 for prospective determination of the thresholds, whereas PostStudy means reports that were newly picked up in the same manner as for the PreStudy, at the end of this study, in December 2003), viz age (63 to 71 years), NIHSS score (11 to 15), and time from onset to treatment (124 to 164 minutes), were comparable to those of the present study.

The safety and efficacy outcomes are summarized in the Figure and Table 2. The proportion of favorable outcomes was 36.9%, well exceeding the predetermined threshold of 33.9%. Concerning the secondary efficacy end points, 50 patients (48.5%) had a BI of 95 to 100 at 3 months compared with 50% of the rt-PA arm and 38% of the placebo arm in the NINDS study (part 2).[1] Fifty-one patients (49.5%) experienced improvement by ≥4 points or a decrease to 0 points on the NIHSS at 24 hours after stroke onset compared with 47% of the rt-PA arm and 39% of the placebo arm in the NINDS study (part 1).[1] The median NIHSS scores were 15 points at baseline and 10.5 points at 24 hours in this trial (ie, close to the median NIHSS change [5 to 6 points] of the rt-PA arm and larger than that of the placebo arm [1 to 2 points] in the NINDS study).[1] All efficacy end points in our trial were closely comparable to those of the rt-PA arm in the NINDS study.

TABLE 2. Results of J-ACT and NINDS Studies

	J-ACT	NINDS*	
		rt-PA	Placebo
mRS score 0–1 at 3 months	36.9%	39%	26%
BI 95–100 at 3 months	48.5%	50%	38%
NIHSS improvement by ≥4 points or decreased to 0 at 24 hours	49.5%	47%	39%
sICH within 36 hours	5.8%	6.4%	0.6%
Death within 3 months	9.7%	17%	21%

*As the NINDS study values, the mRS and BI from part 2, NIHSS improvement from part 1, and sICH from parts 1 and 2 are presented because these were treated as the primary end points in the trial.[1]

J-ACT indicates Japan Alteplase Clinical Trial.

Six patients (5.8%) had sICH within 36 hours (Table 3). This incidence was lower than the predetermined threshold of 9.6%, and similar to that of the rt-PA arm in the NINDS study. Four of the 6 cases of sICH revealed hematoma on CT, which corresponded to parenchymal hematoma-2 on the European Cooperative Acute Stroke Study (ECASS) criteria;[6] the other 2 cases were of hemorrhagic infarction. Two patients with sICH died, 1 within 24 hours after stroke onset and the other on day 3. Within 10 days, the CT Film Reading Panel identified 26 patients (25.2%) with hemorrhagic infarction and 12 patients (11.7%) with hematoma, of whom 9 also exhibited shifts of the midline structures. Asymptomatic ICH was detected in 17% and 31% of patients within the initial 36 hours and 10 days of treatment, respectively.

Ten patients (9.7%) died within 90 days after onset. This mortality was somewhat lower than that reported in rt-PA–treated patients (10% to 17%).[1,6,7,12,13]

Discussion

The primary efficacy and safety end points were within the predetermined thresholds, based on a meta-analysis of published studies, and approximated to those of the rt-PA arm in the NINDS trial. All secondary end points were also similar to those of the rt-PA arm. The baseline factors known to affect outcome, including age, severity of stroke, diabetes, and hypertension, were comparable to those in the NINDS study. The age and stroke severity of the study population were similar to or slightly higher than those in previous reports. None of the baseline characteristics appeared to affect outcomes favorably in this study. Before inferring that 0.6 mg/kg intravenous alteplase for Japanese patients is consistent with the 0.9 mg/kg used in North America and the

TABLE 3. Six Cases With sICH

Age	Onset to Treatment Time (min)	Baseline NIHSS score	Baseline Blood Pressure (mm Hg)	Treatment to Hemorrhage (CT)	3 Months mRS	CT Findings*
63	170	7	142/82	21 hours, 29 minutes	4	(3)
80	171	20	166/76	20 hours, 29 minutes	5	(3)
70	148	24	164/82	1 hour, 12 minutes	Death	(3)
77	115	24	185/71	22 hours, 25 minutes	5	(1)
81	134	19	176/96	21 hours, 9 minutes	4	(2)
72	179	20	150/64	18 hours, 20 minutes	Death	(1)

*Findings according to the CT Film Reading Panel assessment.
(1) Hemorrhagic infarction without hematoma.
(2) Hematoma without shift of the midline structures.
(3) Hematoma with shifts of the midline structures.

European Union (EU) with regard to efficacy and safety, we need to consider the issue of dose rate and limitations of the present study.

The rationale for our decision to use 0.6 mg/kg instead of 0.9 mg/kg was based on dose-rate findings of duteplase trials for acute stroke completed in Japan a decade ago.[3–5] This lower dose is considered optimal for longer-elapsing patients up to 6 hours after onset because the risk of intracerebral hemorrhage may rise. Assuming that lower-dose rt-PA is associated with a better risk/benefit ratio in patients beyond 3 hours of stroke onset, a pilot study of 0.6 mg/kg intravenous alteplase has been conducted.[17] Nevertheless, the optimal dosage for acute ischemic stroke might need reassessment because the optimal dose has not been fully explored. Even pilot dose-escalation studies for the NINDS rt-PA trial[18,19] did not yield any conclusive findings. Another reason behind our preference for a lower dose is racial differences in blood coagulation–fibrinolysis factors, such as fibrinogen and factor XIII.[20] Comparing the dose-rate findings of alteplase studies for acute myocardial infarction between Japan and North America/EU may point to racial differences in dose rate. The optimal dose to attain a coronary patency rate of 65% to 80% was estimated at 0.5 to 0.75 mg/kg in Japan, which was lower than the recommended dose (≈1.25 mg/kg) in North America/EU.[20] Data analysis in the acute myocardial infarction studies demonstrated differences in response between blacks and whites after thrombolytic therapy with rt-PA; black patients revealed a greater thrombolytic efficacy and more hemorrhagic events.[21] For US/EU stroke patients within 8 hours of onset,[22] duteplase between 0.29 MU/kg and 0.75 MU/kg achieved a recanalization rate of almost 40%, which is comparable to the results of the Japanese duteplase trials[3–5] at 0.33 to 0.5 MU/kg. Because of the limited sample sizes, no apparent dose rate was evident. Differences in the efficacy and safety of duteplase and alteplase for ischemic stroke among different races remain to be explored.

The present trial design was a prospective open-label cohort study without controls. The disadvantages and limitations of such a design are self-evident. The lack of a control group is the most critical issue. However, it would be impracticable to conduct a randomized placebo-controlled trial under the present circumstances. Because intravenous duteplase trials had already indicated benefits, intravenous alteplase had been approved and used worldwide, and a substantial proportion (3%) of patients with acute ischemic stroke in Japan had received thrombolytic therapy.[2] Given that the development of duteplase was aborted by a patent suit despite appropriate placebo-controlled trials showing benefits, the usual acceptable standard of trial design could not be conducted, and the use of thrombolytic agents for ischemic stroke was abruptly halted in Japan a decade ago. Although the present design uses "historical controls," there is no other way to perform this trial in the current climate ethically. Where treatments affect survival or irreversible morbidity, placebo-controlled trials cannot be conducted ethically. Equivalence study design may be an alternative choice.[23] In the present study, similarity of safety and efficacy outcomes was assessed by comparison with those available from a meta-analysis of the literature. Although our study lacked a control group, the efficacy and safety results are consistent with the data of the systematically reviewed studies. The point estimate in this study was within the CI in 100 patients calculated through the meta-analysis. This fact indicates that, assuming the efficacy and safety of alteplase are equivalent to the published experience, this point estimate can be considered to be within the expected range for a study involving 100 patients. Furthermore, another systematic review conducted in December 2003 confirmed the consistency of the original meta-analysis (see bottom part of Figure, where PostStudy means reports that are newly picked up in the same manner as for the PreStudy, at the end of this study). The weighted average of the proportion of mRS score of 0 to 1 at 3 months was 39.0% (among 1140 patients; 90% CI, 36.7% to 41.4%) in total from 9 reports providing information on the mRS score of 0 to 1 at 3 months.[1,6,7,24–29] The weighted average of the incidence of sICH was 5.4% (among 2927 patients; 90% CI, 4.7% to 6.1%) from 16 reports containing information on sICH.[1,8–11,13,14,24–27,30–34] These ranges of CI values should contain the almost true mRS 0 to 1 proportion and sICH incidence with 0.9 mg/kg alteplase, which overlap entirely with the respective 90% CI values in the present trial of 29.1% to 44.7% for the mRS 0 to 1 proportion and 2.0% to 9.6% for sICH.

Another possible problem with this trial was detection bias because outcome measurement was not blinded. Although detection bias effects cannot be ruled out, the outcomes were