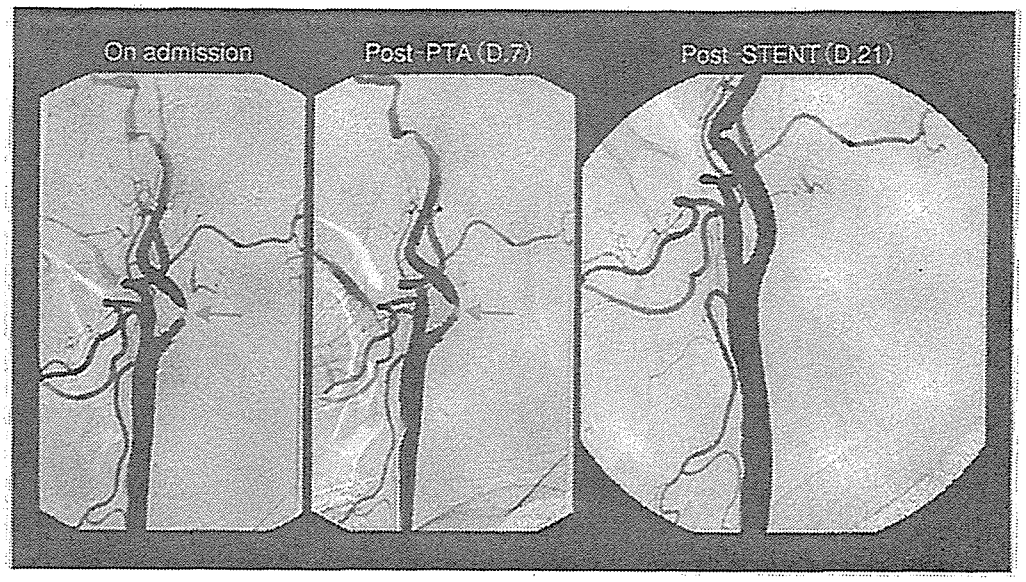

図7　PTAにより改善がみられた内頸動脈狭窄性病変症例の脳血管造影 (1)

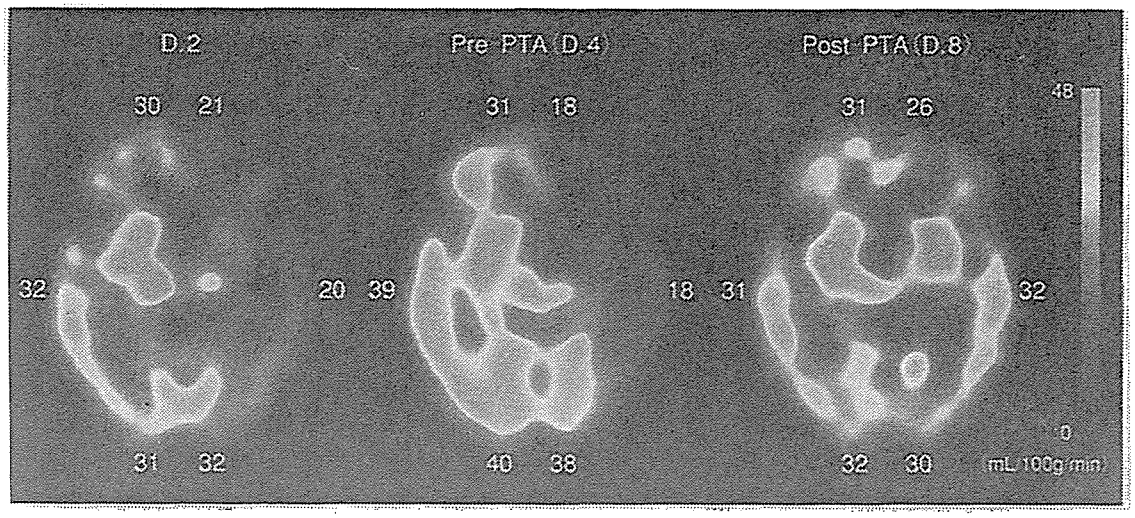

図8　PTAにより改善がみられた内頸動脈狭窄性病変症例の脳血流SPECT (2)

の急性期症例を以下に呈示する。

76歳，女性：左内頸動脈に9割以上の狭窄があり，7日目にPTAを行ったところ，脳血流が改善し，3週目にステントを留置した(**図7**)。エコーでは入院時のpeak systolic velocityが400 cm/sを超えており，五つの薬物治療でも約300 cm/sであったが，PTA施行後に182 cm/sとなり狭窄度の改善がみられた。PTA治療前まで脳血流はクリティカルレベルに推移していたが，治療後のわずかな狭窄の改善により脳血流は正常化した(**図8**)。血行力学的虚血の場合には，脳灌流圧のわずかな改善によって脳血流が正常化することが認められた。

64歳，男性：右内頸動脈に狭窄があり，脳血流も中大脳動脈領域全体で低下している状態であり，治療前の脳血管造影では、浮遊している壁在血栓がみられ，末梢は塞栓性閉塞のような状況になっていた(**図9**)。薬物治療5日後には脳血流が正常化し，14日後の脳血管造影では壁在血栓が消えて，狭窄だけが残っていた(**図10**)。エコーをみると浮遊していた壁在血栓は溶解していた。薬物治療によって劇的な改善が認められた症例であり，最終的にはCEAを行った。

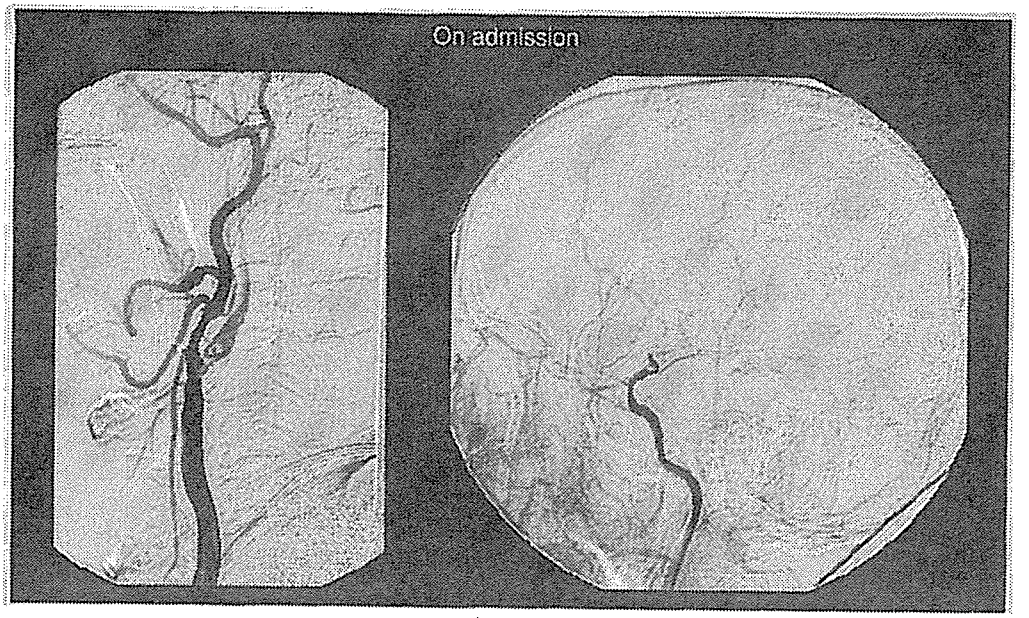

図9 急性期薬物治療前の内頸動脈狭窄症例の血管造影 (1)

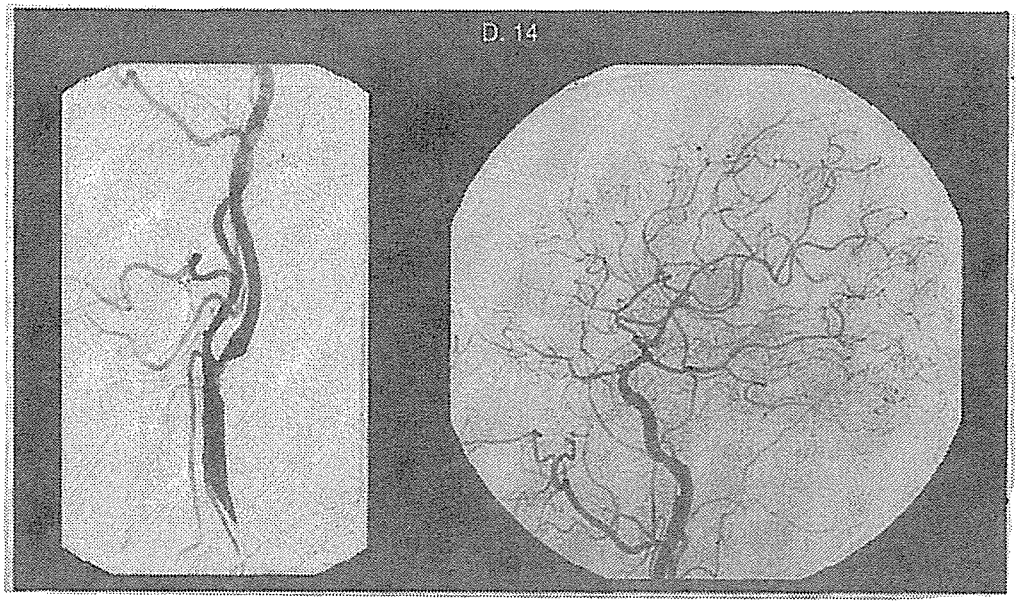

図10 急性期薬物治療後の内頸動脈狭窄症例の血管造影 (2)

6) progressing strokeに対する血管内治療

急性期の狭窄症例に対してCEA，あるいはステントを施行する際，現時点では抗凝固あるいは抗血小板等の薬物治療で初期経過を観察し，治療のタイミングをはかることが原則と考えられる。

ただしprogressing strokeに対する血管内治療では，PTA後の急性閉塞を考慮して，ステントによるバックアップを常に考えなければいけない。また，不安定アテローム血栓の破砕に対して十分な抗凝固治療を併用する。さらに，血行力学的脳虚血の軽症化を治療の目標とする場合には，狭窄のわずかな改善による脳灌流圧の上昇によっても脳血流が改善する。急性期治療には血管内治療も含むストラテジーを考えておく必要がある。

急性期アテローム血栓性脳梗塞にみられるprogressing strokeは，血行力学的脳虚血Stage

IIの中でも最重症のクリティカルグループに相当し，まだエビデンスレベルは低いが，神経学的な増悪が考えられる進行症例に対して上記の血行再建治療を考慮する必要がある。

ま と め

脳梗塞急性期にはCTやMRIによる組織診断，灌流画像を用いたpenumbraの診断，責任血管病変の同定を行い，場合によっては血行再建というオプションも考慮する必要がある。

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討　論　　座長　日本大学医学部脳神経外科　片山容一

片山　中川原先生，ありがとうございました。急性期の血行再建が重要であるという意見を示されました。その時点でのストロークの病態にはあまり関係なく，血行力学的な改善を図るのがよいと理解しましたが，それでよろしいでしょうか。

中川原　血行力学的脳虚血の重症度がステージIIの範疇に入るグループで，梗塞が皮質下に限局する症例に対して急性期の血行再建が重要と思われます。JET研究が行われた約6年間，われわれは急性期バイパスを行いませんでした。保存的治療では，皮質下に大きな梗塞をつくってしまい，アウトカムは極めてよくないという結果でした。血行力学的な急性期脳虚血で，皮質梗塞が回避されているグループに対しては，何らかの血行再建を考える必要があります。ただ，薬物治療で脳循環動態が改善する場合がありますので，発症から3日目，4日目でも神経症状の進行がある場合にオプションとしてのバイパス，あるいは血管内治療を考慮すべきであると考えています。

片山　ありがとうございました。

脳ドックの現状と課題

中川原　譲二[1)]

1）なかがわら　じょうじ／中村記念病院脳神経外科　部長

◇脳ドックについては、無症候性の脳および脳血管疾患の早期発見と予防という点から大きな期待がかけられているが、その自然経過、薬物や手術による介入の影響については、いまだエビデンスレベルの高い知見がほとんど集積されていない。

◇今後、脳ドックの有用性が確立されるためには、検診結果についての判定と指導を標準化し、データベース化することにより、将来の疾病がどの程度防止されるかをEBMの観点から科学的に検証することが課題となる。

◇日本脳ドック学会が策定した『脳ドックのガイドライン2003』に基づいて、最近の脳ドックで推奨されている検査対象と標準的な検査方法について解説するとともに、脳ドックで見つかった無症候性の脳血管疾患に対する対処方法について述べた。

KeyWords

脳ドック
MRI
MRA
無症候性脳梗塞
無症候性脳出血
未破裂脳動脈瘤

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はじめに

日本脳ドック学会が策定した『脳ドックのガイドライン2003』[1]によると、脳ドックの目的は、「無症状の人を対象に、MRI（磁気共鳴画像診断）、MRA（磁気共鳴血管画像診断）による画像診断を主検査とする一連の検査により、無症候あるいは未発症の脳および脳血管疾患あるいはその危険因子を発見し、それらの発症あるいは進行を防止すること」とされている。そして、脳ドックで発見される代表的異常所見としては、表1に示す病変などがあり、現時点における知見に基づいて推奨される指針が示されている。

この新しい形の検診については、無症候性の脳および脳血管疾患の早期発見と予防という点から大きな期待が寄せられているが、その自然経過、薬物や手術による介入の影響については、いまだエビデンスレベルの高い知見がほとんど集積されていないことが問題点である。本稿では、最近の『脳ドックのガイドライン2003』で推奨されている検査対象と標準的な検査方法について解説するとともに、脳ドックで見つかった無症候性の脳血管疾患に対する対処方法について述べる。

表1　脳ドックで発見される代表的異常所見

1）症候性脳梗塞
2）大脳白質病変
3）無症候性脳出血
4）無症候性・脳主幹部動脈狭窄・閉塞
5）無症候性未破裂脳動脈瘤
6）無症候性脳動静脈奇形・海綿状血管腫・もやもや病
7）無症候性脳腫瘍および腫瘍様病変

表2 脳ドックで行われる検査項目

1)問診および診察(必須)
2)血液・尿・血液生化学検査(必須)
3)心電図検査やduplex血管超音波検査
4)認知症のスクリーニング検査として脳血流SPECT検査や心理検査(オプション)
5)MRI診断〔T_1強調画像、T_2強調画像、FLAIR画像(またはプロトン密度画像)、およびT_2*強調画像〕
6)MRA診断(頭部は3D-TOF法、動脈は2D-TOF法もしくは3D-TOF法)

検査対象と整備すべき機器と設備

脳ドックの積極的な対象は中・高齢者であり、リスクの低い若年者や超高齢者は積極的な対象とはならない。さらに中・高齢者のなかでも、脳卒中の家族歴、高血圧、肥満、喫煙などの危険因子を有するハイリスク群に対して重点的に受診を勧めるべきである。また、受診時や受診結果の説明時には、脳ドックの目的と意義、検査の内容とリスク、発見された異常所見とその対処法などについて十分に説明し、受診者の納得を得ることが必要である(適切なインフォームドコンセントが必要)。

脳ドックで行われる検査項目(**表2**)は一律ではないが、診断に値する検査の精度が常に確保されなければならない。整備すべき機器と設備として、高性能MR装置、高次脳機能検査のためのソフトと人材、血液生化学検査システム、心電図測定機器、脳ドック専用診療録、インフォームドコンセントのための部屋、脳ドック受診者の控え室、超音波検査機器、などが推奨されている。

検査項目とその目的

問診および診察、血液・尿・血液生化学検査は必須であり、これらは脳卒中の一次予防のための介入可能な疾患を検出するために行われる。心電図検査やduplex血管超音波検査は、危険因子のスクリーニング検査として推奨される。特に血管超音波検査では、Bモード断層法とパルスドプラ法を組み合わせて、アテロームプラークや狭搾・閉塞病変の観察や血流速度の計測を行う[2]。動脈硬化の初期変化の検出は、他の危険因子との関連の把握や心血管系の血管事故の予知などにも役立つ。その他の選択(オプショナル)検査では、認知症のスクリーニング検査として脳血流SPECT(単光子放射型コンピュータ断層撮影法)検査や心理検査などが行われる。

MRI診断は、主として無症候性脳梗塞や大脳白質病変、無症候性脳出血の検出のために行われる。従って、少なくとも10mmかそれより薄いスライスで撮像されたT_1強調画像、T_2強調画像、ならびにFLAIR画像(またはプロトン密度画像)および可能な限り微小出血痕検出のための画像(T_2*強調画像)を含む鮮明な頭部軸位画像で行うことが推奨されている。

無症候性の脳ラクナ梗塞のMRI所見は、T_2強調画像、FLAIR画像(またはプロトン密度画像)のいずれかで、周辺が不明瞭で不規則な型をした最大3mm以上の高信号域を呈し、T_1強調画像で同部に低信号が見られる[3]。

一方、鑑別すべき拡大血管周囲腔(état cribré)の所見の特徴は、大きさが3mm未満、一般に整形で均質、周囲に信号変化を伴わない、穿通動脈、髄質動静脈の走行に沿う、などである。ただし、大脳基底核下3分の1の部位の拡大血管周囲腔ではしばしば左右対称性で、径3mmを超えることも少なくない[4]。血腫瘢痕は多くは線状、三日月状ないし円弧状の病変で、T_1強調画像で中心部が低信号、T_2強調画像で高信号である。T_2強調画像にて周辺部にヘモジデリン沈着による輪状の低信号が見られる。微小脳出血(micro bleeds)[5,6]はT_2*強調画像にて多くは多発性の低信号として認められる。

大脳白質病変は、T_2強調画像やFLAIR画像(またはプロトン密度画像)上で脳室周囲白質や深部・皮質下白質に高信号病変を呈し、T_1強調画像では等信号あるいは大脳灰白質と同程度の軽度低信号を示す。大脳白質病変は脳室周囲病変(Periventricular hyperintensity：PVH)と深部皮質下白質病変に分けられる。

MRA診断は、未破裂脳動脈瘤ならびに頭部の主幹動脈の閉塞・狭窄病変や、動脈の狭窄・閉塞を検出するために行われる。前者の検出では、3D-TOF(time of flight)法による撮像を原則とする。画像は、ウイリス輪を中心にして、①左右方向に角度を変えた画像と②前後方向に角度を変えた画像を作成

する。立体視が可能な角度で回転させた画像であることが望ましい。後者の検出では2D-TOF法もしくは3D-TOF法により撮像する。撮像範囲は総頸動脈分岐部を中心に総頸動脈、外頸動脈、内頸動脈が含まれるようにし、左右方向に角度を変えた画像を作成する。最近では脳動脈の三次元的描出も可能(3D-MRA)となり、頭蓋内の未破裂脳動脈瘤や脳主幹動脈の閉塞・狭窄の検出精度の改善が得られている。

無症候性の脳血管疾患に対する対処方法

無症候性脳梗塞は脳卒中の高危険因子である。無症候性ラクナ梗塞に対する抗血小板療法は、症例に応じて慎重に行うべきである[7]。無症候性脳梗塞の最大の危険因子は高血圧であり、高血圧例には適切かつ十分な降圧療法が必要である。患者への説明には十分な注意を払い、いたずらに不安感を募らせないようにすべきである。無症候の境界域(分水嶺)脳梗塞では、その心臓側の脳主幹動脈の狭窄・閉塞を詳しく検討する必要がある。

大脳白質病変のうち、特に高度なPVHを有する症例は脳卒中発症の高危険群である可能性があり、治療可能な危険因子、特に高血圧に対して積極的治療を行う。高度な白質病変は認知機能低下、前頭葉機能の低下を来す可能性があり、危険因子の治療は血管性痴呆の予防の観点からも重要である[8]。

無症候性微小脳出血(micro bleeds)は、症候性脳出血を生じる可能性があるため、積極的な血圧管理が必要である。

無症候性・脳主幹動脈の狭窄・閉塞には専門医による注意深い評価が勧められる。禁煙・節酒を勧め、高血圧、高脂血症、糖尿病などの危険因子の治療を行う。頸動脈の無症候性高度狭窄では、抗血小板療法を含む内科的治療に加え、頸動脈内膜剥離術が推奨される[9]。頸動脈内膜剥離術は手術および周術期管理に熟達した施設で行う。無症候性主幹動脈閉塞・狭窄病変に対しては脳循環検査を行い、専門医による評価の上、必要に応じて抗血小板療法を行う。

未破裂脳動脈瘤が発見された場合は、その医学的情報について正確かつ詳細なインフォームドコンセントが必要である。脳動脈瘤が硬膜内にある場合は、原則として手術的治療(開頭術あるいは血管内手術)を検討する。一般に、脳動脈瘤の最大径が5mm前後より大きく、年齢が70歳以下で、その他の条件が治療を妨げない場合は手術的治療が勧められる。最太径が3～4mmの病変、また70歳以上の場合にも脳動脈瘤の大きさ、形、部位、手術のリスク、患者の平均余命などを考慮して個別的に判断する。

手術が行われない場合は、発見後6か月以内に画像による脳動脈瘤の大きさ、形の変化、症候の出現などの観察が必要で、増大あるいは突出部(bleb)の形成が認められた場合には手術的治療を勧める。変化のない場合は、その後少なくとも1年間隔で経過観察を行う。観察期間中は喫煙、高血圧など、脳動脈瘤破裂にかかわる危険因子の除去に努める。脳動脈瘤が発見されなかった場合、3年以内の再検査の必要性は低いとされる。

現在わが国では、未破裂脳動脈瘤の自然歴および治療の危険性に関与する因子の同定、未破裂脳動脈瘤の大規模なデータバンクの構築を目指して日本未破裂脳動脈瘤悉皆調査(UCAS Japan)[10]が進行している。その結果により、未破裂脳動脈瘤に対するより合理的な治療指針が今後確立するものと考えられる。

おわりに

脳ドックは、画像検査技術の進歩により必然的に生まれた新しい形の脳および脳血管の検診であり、わが国ではMR機器の導入数の増大とともに急速に普及した。脳卒中の発症あるいは進行を防止するための脳ドックは、言うまでもなく、各種画像検査による無症候性脳血管病変の診断にとどまることなく、危険因子のコントロールと一体のものとして管理されなければならない。従って、各医療機関で脳ドックを行う場合には脳卒中専門医による対応が必要である。

今後、脳ドックの有用性が確立されるためには、検診結果についての判定と指導を標準化し、データベース化することにより、将来の疾病がどの程

度防止されるかをEBMの観点から科学的に検証することが課題となる。そうした取り組みによって、はじめて脳ドックの医療経済上の効果についても検証されるに違いない。予防医学としての脳ドックを普及発展させるためには、根拠に基づいた正しい利用法と有用性の確立こそが重要である。

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6 病型別，年代別，性別にみた脳卒中の地域間（札幌と全国）比較

▶当該地域の脳梗塞の病型は，J-MUSICに登録された全国調査と比較して，アテローム血栓性脳梗塞，ラクナ梗塞の頻度は同等で，心原性脳塞栓の頻度が比較的高かった．
▶男女とも心原性脳塞栓の頻度が，50歳代を境に高齢になるほど高くなる傾向にあった．
▶脳出血の部位別頻度は，秋田県脳卒中発症登録データと比べ脳幹出血が高率であった．
▶部位別の発症年齢では，男性の脳幹出血，男女の尾状核出血が若年発症であった．

2000年1月から2004年11月までに当院（札幌市）の急性期脳卒中入院台帳に登録された4,091例の患者データのなかから，急性期脳卒中の地域における実態を知る目的で，脳梗塞と脳出血の病型別，年代別，性別頻度を調査し，これまでに報告された他地域の調査と比較した．

脳梗塞

従来，わが国の脳梗塞ではラクナ梗塞の頻度が高いとされてきたが，2001年に報告された山口班（J-MUSIC）の全国調査[1]では，ラクナ梗塞の減少とアテローム血栓性脳梗塞の増加がみられ，大都市圏で両者の頻度が逆転した．2000年1月から2004年11月までの約4年間に当院の脳卒中入院台帳に登録された脳梗塞2,743例の病型分類をみると，3大病型のうち，心原性脳塞栓が26.9％，アテローム血栓性脳梗塞が30.6％，ラクナ梗塞が34.7％であった（図1）．各病型の頻度はJ-MUSICの全国平均の結果と比較して，アテローム血栓性脳梗塞，ラクナ梗塞の頻度は同等で，心原性脳塞栓の頻度が比較的高かった．ラクナ梗塞とアテローム血栓性脳梗塞の頻度に逆転はみられないものの，アジア型から欧米型へと移行しつつある傾向は，わが国の地方都市でも確実に進行している．

当院で登録された脳梗塞の発症平均年齢は69.6歳（J-MUSICの解析結果と同等）で，男性が67.5歳，女性が72.9歳であり，3大病型ともに女性が5〜6歳高齢であった（図2）．また，性別発症頻度については，脳梗塞全体では男性が1,693例61.7％，女性が1,050例38.3％で，3大病型のなかではアテローム血栓性脳梗塞の頻度が男性で65.0％と若干高かった．

年代別にみると，脳卒中急性期患者データベース（JSSRS）研究[2]と同様に，男女ともに心原性脳塞栓の頻度が若年代で高く，50歳代を境に高齢になるほど高くなる傾向にあった（図3，図4）．高齢者における非弁膜性心房細動（nonvalvular atrial fibrillation; NVAF）の罹患率の漸増との関連が示唆された．

脳出血

2000年1月から2004年11月までに当院で登録された脳出血例は868例で，全脳卒中に占める割合は全体の21％前後であった．近年，脳出血の割合は脳梗塞の増加により相対的に減少していると思われるが，脳卒中のわずか10％を占めるにすぎない欧米よりもはるかに高い頻度である．登録症例の出血部位別の頻度は図5のようになり，その相対頻度は秋田県脳卒中発症登録のデータ[3]と比較して，脳幹出血の頻度が10.4％と高かった．当院で登録された脳出血の発症平均年齢は64.5歳で，男性が62.4歳，女性が67.3歳であり，女性が5歳前後高齢であった（図6）．部位別の発症年齢をみると，男女とも出血部位によって発症年齢が異なり，男性では脳幹出血と尾状核出血，女性では尾状核出血が比較的若年発症で，男女ともに視床出血，皮質下出血，小脳出血が比較的高齢発症であった．性別発症頻度については，男性が501例57.7％，女性が367例42.3％であったが，脳幹出血では男性の頻度が66.7％と高く，尾状核出血では女性の頻度が56.7％と高かった．

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図1　脳梗塞患者の臨床病型分類

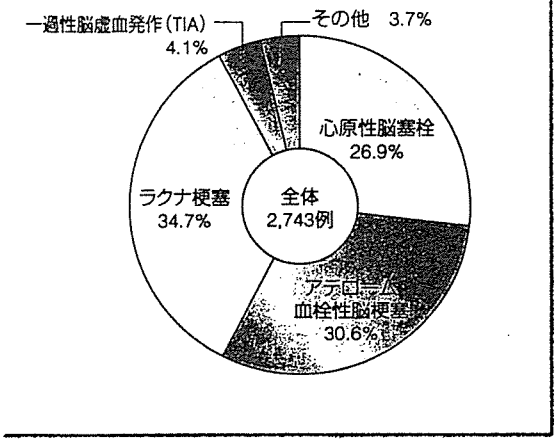

図2　脳梗塞患者の病型別・性別平均年齢と標準偏差

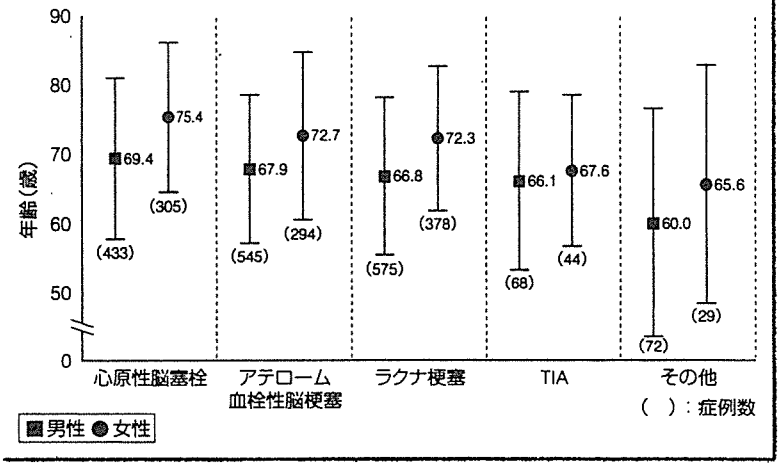

図3　年代別の男性脳梗塞患者の臨床病型分布

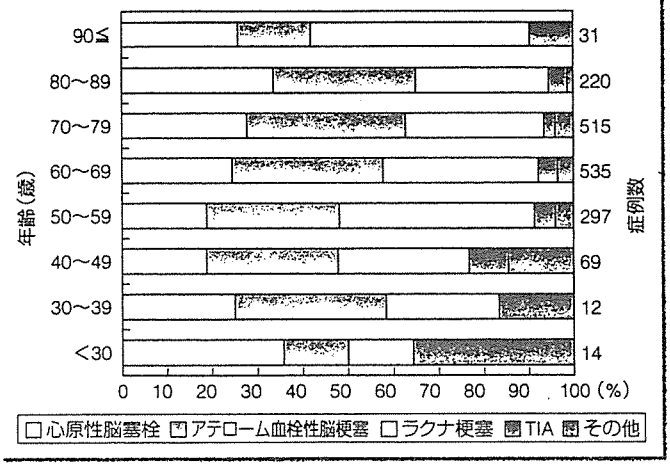

図4　年代別の女性脳梗塞患者の臨床病型分布

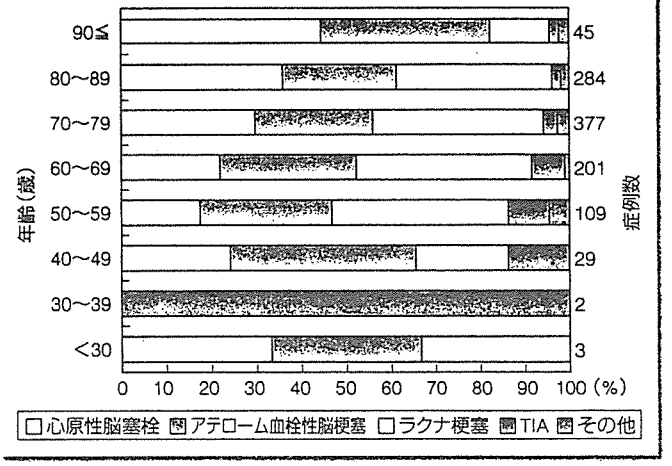

図5　脳出血患者の出血部位別分類

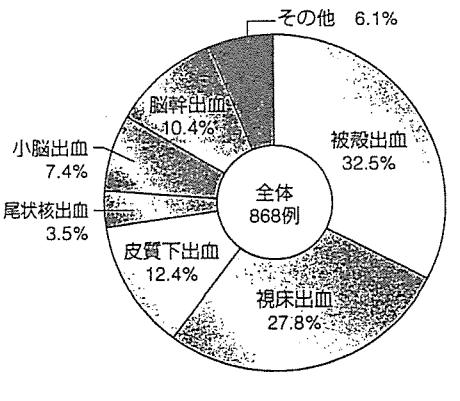

図6　脳出血患者の出血部位別・性別平均年齢と標準偏差

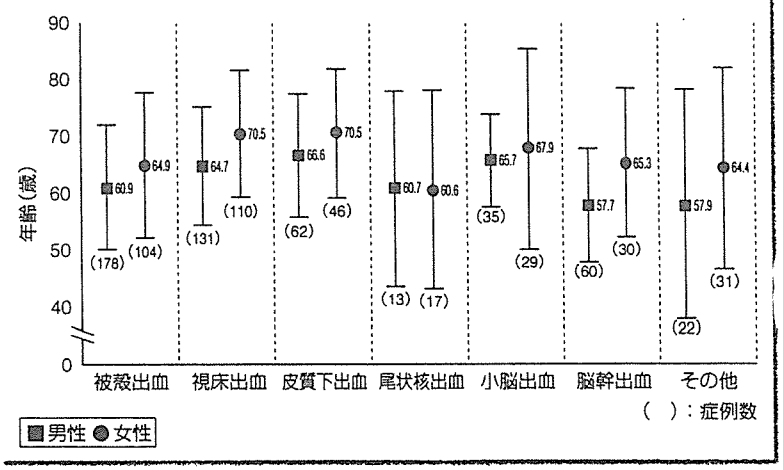

図1～6のデータは，いずれも2000年1月～2004年11月までに登録されたものである．

SCALED SUCTION FOR MICRONEUROSURGERY: TECHNICAL NOTE

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OBJECTIVE: We have developed scaled suction to facilitate the measurement of aneurysm neck width and tumor size during operations.

METHODS: We constructed a new suction device scaled every 1 mm from the tip to 3 cm and every 5 mm from 3 to 5 cm. The scaled suction devices have been used in 50 aneurysm and brain tumor operations.

RESULTS: The new suction device permits easy measurement of aneurysm neck width, tumor size, the extent of internal decompression of tumor, and depth from the surface of the brain to the lesion.

CONCLUSION: Our scaled suction device is a simple and useful navigator for continuously measuring intraoperative variables such as lesion size and distance between the lesion and the surrounding vital structures.

KEY WORDS: Brain tumor, Cerebral aneurysm, Microsurgery, Scale, Suction

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Accurate determination of the size of a lesion and the distance between the lesion and surrounding structures is essential for safe and steady intracranial surgical procedures (1, 2). As the operative field is opened step by step to accomplish each operative exposure, these measurements should be easily repeatable during microsurgical procedures. Conventionally, these variables have been measured by placing a scale into the operative field. This method provides a rough estimate of lesion size but is difficult to use continuously in a hemorrhagic and/or deep operative field. To overcome these problems, we have designed scaled suction devices, which can be used as a continuous intraoperative monitor to estimate the size of lesions and the distances between the lesion and surrounding structures.

MATERIALS AND METHODS

A scaled suction device was constructed using pure titanium (Japanese Industrial Standard Grade 2, titanium ≥99.85%) (*Fig. 1B*). Each scale was marked entirely on the surface every 1 mm, from the tip to 3 cm, and every 5 mm from 3 to 5 cm (*Fig. 1A*). Five different sizes of scaled suction device of 1; 1.5, 2, 2.5, and 3 mm in internal diameter were made. The scaled suction instruments have already been used in 30 aneurysm and 20 brain tumor operations.

RESULTS

Figure 1, C and *D*, illustrates the application of the scaled suction device in an operative field. The patient was a 55-year-old woman who was found to have a right middle cerebral artery aneurysm during a brain examination. The aneurysm had a relatively wide neck (*Fig. 1C*), estimated to be approximately 6 mm by our scaled suction device. We selected a straight clip, 11 mm long, as the most suitable for clipping the aneurysm. During the aneurysm surgery, we were able to measure not only the aneurysm size but also the depth of the operative field and the distance between the lesion and the surrounding vital structures, such as the perforators. These intraoperative measurements facilitated selection of clips of suitable sizes and enhanced the accuracy of clip blade placement. During tumor surgery, the tumor size, depth of extension of the tumor, and depth from the surface of the brain to the lesion were easily estimated by our scaled suction instrument. The intraoperative measurements with our scaled suction device were performed without incident in 50 microneurosurgeries for cerebral aneurysms and brain tumors.

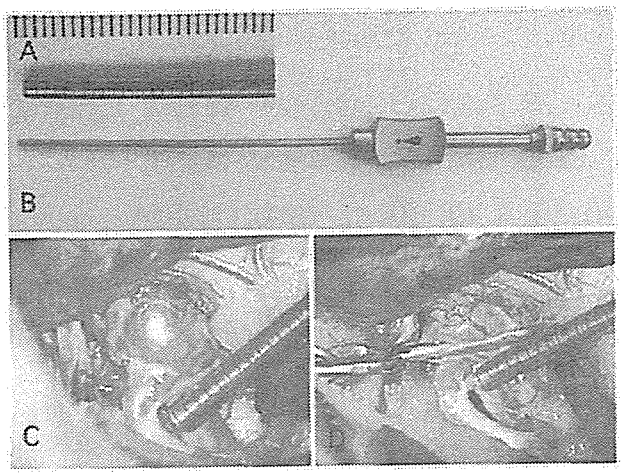

FIGURE 1. A *and* B, *pure titanium scaled suction (2-mm internal diameter). Each scale is sharply marked on the surface every 1 mm, from the tip to 3 cm.* C *and* D, *intraoperative photographs showing the scaled suction being used to assess the aneurysm size and neck width.*

DISCUSSION

Our newly developed scaled suction devices have permitted easy, rapid, and consistent measurements of the sizes of lesions as well as the distances between lesions and the surrounding vital structures during microsurgical manipulations. Various types of scaled instruments have been designed and are helpful for establishing orientation in neurosurgery (1, 2). Mizutani (2) developed scaled clips for aneurysm surgery, applied these clips in 40 aneurysms, and confirmed their usefulness. Suctions, however, are the most frequently used instruments in microneurosurgery. Constant intraoperative placement of a scaled instrument can facilitate intraoperative quantitative analyses of the size of the lesion and the distance between the lesion and corresponding structures, such as an aneurysm and its parent artery. From this point of view, scaled suction instruments serve as one of the most important navigation devices and as a constant detector of the width and depth of a lesion and the operative field. In conclusion, our newly developed scaled suction instrument is simple, safe, and useful for neurosurgical procedures.

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COMMENTS

The authors have described a scaled suction instrument. This is a logically and practically sounded add-on design. It allows a surgeon to measure the neck of an aneurysm directly to facilitate selection of a proper length of clip and is also useful for surgery for a deeply located tumor.

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Okada et al. have presented a set of tubes having marks every millimeter from the tip for 3 cm and every 5 mm thereafter from 3 to 5 cm. The suctions are available in a variety of sizes. It is common to use a suction tube for both suction and dissection around the neck of an aneurysm or in defining the margins of a tumor. It seems appropriate to place a scale on the suction as an aid to selecting the appropriate aneurysm clip or to measure how much of a tumor has been removed. The findings from this scale can also be correlated with results from image guidance. Other instruments typically used around an aneurysm or tumor include dissecting bayonets and various dissectors like the Rhoton Numbers 6, 7, and 8 (1). It seems reasonable to consider placing a scale on other instruments commonly used in dealing with tumors and aneurysms.

The authors list the inner diameters of their suction tubes in millimeters related. A more common practice in the United States is to describe suction tube diameter in terms of the French units. Each French unit is a third of a millimeter outer diameter, so a 3-French tube would have a 1 millimeter outer diameter and a 6-French would have a 2 millimeter outer diameter.

The most delicate neurosurgery is done with a suction tube held in a pencil grip with the hand rested on the margin of the wound. Some suction tubes, such as the Frazier tube, are designed to be held in a pistol grip with the hand floating in the air above the wound. We prefer the type of suction with the hand held in a pencil grip with the hand rested on the wound margin, because this allows for a more accurate and delicate dissection. Resting the hand on the margin of the wound and reaching the target sites requires that the length of the suction be sized to the depth of the target area.

Our tubes range in diameter from 3- to 12-French and are available in three lengths: superficial length for work at the surface, a deep length for work in areas such as the CP angle and the circle of Willis, and an extra deep set for use at sites such as in the front of the brainstem and in transsphenoidal surgery (1). We have also added atraumatic tips to the suction tubes.

Okada et al. have demonstrated an innovation, which could be applied to other instruments in addition to suction tubes. Most instrument makers will be willing to add marks like those presented in this article to a surgeon's favorite dissecting instruments.

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1. Rhoton AL Jr: Operative techniques and instrumentation for neurosurgery. **Neurosurgery** 53:1–28, 2003.

Okada et al. introduced a scaled suction for measuring during microsurgery. It is certainly handy and useful because suction is used almost continuously together with bipolar forceps during microsurgical procedures. This scaled suction is especially useful in measuring in a vertical dimension. We can measure in a horizontal dimension to some extent by tilting the suction or guessing from the scale on the suction under the microscope. The reason for using titanium is not explained well, but one would think that malleable materials would better serve the purpose of intraoperative measurement.

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CAROTID TISSUE LEVELS OF ARGATROBAN AFTER DIRECT LOCAL DELIVERY DURING CAROTID ENDARTERECTOMY TO PREVENT PERIOPERATIVE CEREBRAL EMBOLISM

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OBJECTIVE: Argatroban is a synthetic direct thrombin inhibitor. We applied argatroban locally during carotid endarterectomy to prevent local mural thrombus formation. Although local delivery of argatroban is expected to be effective for inhibition of mural clot formation, there is no report of the evaluation of its clinical effectiveness or local drug concentration in humans.

METHODS: Five mg of argatroban (0.5 mg/ml) was applied twice intraoperatively just after arteriotomy for measurement of intraplaque level of argatroban and during closure of the arteriotomy for preventing thrombus formation. After exposure of the carotid plaque to argatroban for a specified duration (0, 3, 5, or 10 min), argatroban was sufficiently washed with saline and the carotid plaque was removed for measurement of tissue concentration of argatroban. Intraplaque level of argatroban was determined by high-performance liquid chromatography. A second application was performed during closure of the arteriotomy. Argatroban was applied for 10 minutes, followed by washing with saline. Postoperative embolic cerebrovascular complications and carotid restenosis also were investigated to verify the efficacy of direct local application of argatroban.

RESULTS: Tissue levels of argatroban in the carotid plaque after 3, 5, and 10 minutes of direct application were 24.0 ± 13.7, 31.6 ± 20.0, and 44.0 ± 15.1 μg/g, respectively. The concentrations at all time points were significantly elevated compared with the control, and a significant difference in concentration was observed between 3 minutes and 10 minutes. In the present study, concentration at 3 minutes was much higher than the effective tissue levels of argatroban reported in experimental studies. No patient developed postoperative cerebrovascular complications.

CONCLUSION: The results suggest that direct local application of argatroban during carotid endarterectomy for at least 3 minutes may deliver high local tissue levels. Argatroban may be effective for prevention of perioperative embolic cerebral complications during carotid endarterectomy.

KEY WORDS: Argatroban, Carotid endarterectomy, Embolic, High-performance liquid chromatography, Restenosis, Thrombin, Tissue levels

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Thrombin is the central enzyme in hemostasis, possessing critical actions in coagulation, fibrinolysis, platelet activation, and vascular cell biology. Argatroban {(2R,4R)-4-methyl-1-[N(2)-(3-methyl-1,2,3,4-tetrahydro-8-quinolinesulfonyl-L-arginyl]-2-piperidine-carboxylic acid monohydrate} is a small molecular weight synthetic arginomimetic direct thrombin inhibitor derived from L-arginine, which reversibly inhibits the active site of thrombin (10, 17). Argatroban is active against clot-bound thrombin and is an effective inhibitor of thrombin-induced platelet activation and clotting (9, 10, 17). Argatroban has been approved for clinical use for both prophylaxis and treatment of thrombosis in patients with heparin-induced thrombocytopenia and treatment of various thrombotic disorders, including chronic arterial occlusion, acute cerebral thrombosis, and hemodialysis in antithrombin-deficient patients or in patients with decreased antithrombin (21).

Thrombin has a stimulatory role in angiogenesis and restenosis after angioplasty and atherosclerosis. Although intracoronary stenting represents an important advancement in

percutaneous revascularization technology, limitations such as platelet-mediated clot formation lead to acute and subacute stent thrombosis. The mechanical manipulations in percutaneous coronary intervention, including angioplasty and coronary stent placement, result in additional plaque rupture and damage to the vessel wall, exposing subendothelial components to blood and resulting in the initiation of the clotting cascade and platelet activation (11). Platelet-thrombus deposition primarily mediated by thrombin occurs within minutes after injury, causing acute occlusion and contributing to late restenosis. Therefore, antithrombin agents have been tried to reduce platelet-thrombus formation after arterial injury and stent implantation (3, 5, 11). For this purpose, local delivery of thrombin inhibitors has been reported to have significant effects in reducing platelet deposition and mural thrombus formation after balloon angioplasty or stent implantation, with no effect on systemic coagulability compared with systemic administration of the drugs (11, 13, 20). In previous studies, investigators used catheter-based technology (13, 20) or newly developed stent technology (11) for local delivery.

In carotid endarterectomy (CEA), most of the early cerebrovascular complications have been reported to be embolic in origin (12, 15). Furthermore, signs of emboli during dissection, wound closure, and early postoperative periods have been associated with cerebrovascular complications in CEA (1, 4, 19). We have used argatroban locally during CEA to prevent local mural thrombus formation. After we remove the carotid plaque, we locally irrigate the lumen of the vessels with argatroban when we close the arteriotomy. Although local delivery of argatroban is expected to be effective in inhibiting mural clot formation, there is no report evaluating its clinical effectiveness or local drug concentration in humans (8). We investigated the intraplaque levels of argatroban after intraoperative local delivery during CEA and the rates of early cerebrovascular complications and restenosis to verify whether the present protocol is effective in inhibiting postoperative embolic events and chronic intimal thickening.

PATIENTS AND METHODS

CEA

General anesthesia was used for CEA in all patients. The internal carotid artery was exposed well beyond the carotid plaque. Before carotid cross clamping, heparin was administered intravenously. Protamine reversal was not used. A longitudinal arteriotomy was made over the carotid bifurcation, extending to a level beyond the carotid plaque. A T-shaped silicone shunt system was used routinely in all patients (*Fig. 1A*) (18).

Patient Population and Protocol

Between May 2000 and July 2002, 45 consecutive patients (43 men and 2 women) ranging in age from 42 to 76 years (mean, 66.1 yr), who underwent CEA for cervical carotid stenosis, were studied. Five mg of argatroban (0.5 mg/ml) was

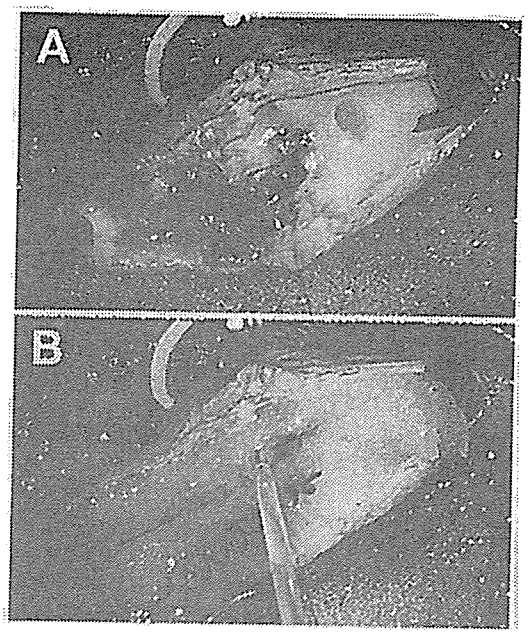

FIGURE 1. *Intraoperative photograph showing placement of the shunt tube (A) and local delivery of argatroban (B).*

applied twice intraoperatively: just after arteriotomy for measurement of intraplaque level of argatroban and during closure of the arteriotomy for preventing thrombus formation (*Fig. 1B*). In the first application, after exposure of the carotid plaque to argatroban for a specified duration (0 [control], 3, 5, or 10 min), argatroban was washed off sufficiently with saline and the carotid plaque was removed for measurement of tissue concentration of argatroban. A second application was performed during closure of the arteriotomy. Argatroban was applied for 10 minutes, followed by washing with saline. The excised carotid plaque was stored immediately at −80°C until measurement. The number of patients in each group was 12, 11, 9, and 13 in control, 3-minute exposure, 5-minute exposure, and 10-minute exposure, respectively. Informed consent for the study was obtained from all patients. The study protocol was approved by the institutional review committee.

Tissue Level Measurement

The cryopreserved carotid plaque segments without soft atheromatous changes were thawed at room temperature and cut cubes smaller than 2 mm. The cut tissues were weighed and homogenized ninefold by weight of water on an ice-water bath. The homogenized suspension samples were stored frozen at −20°C until analysis.

One hundred microliters of the homogenized sample, 100 μl of methanol, and internal standard (nitrazepam) solution were transferred to a test tube. Three hundred microliters of methanol was added to the mixture, shaken for a few seconds, and centrifuged at 10000 rpm for 5 minutes. One hundred microliters of supernatant was separated and mixed with 400 μl of water. The whole volume was filtered with 0.22-μm pore size

membrane filter. Next, 25 μl of the solution was subjected to high-performance liquid chromatography system at a temperature of 50°C.

The concentrations of argatroban were quantified by internal standard method. The range of the calibration curve was approximately 0.5 to 100 μg/g. The lower limit of detection of argatroban as measured by the high-performance liquid chromatography system was 0.5 μg/g.

Rates of Postoperative Cerebrovascular Complications and Carotid Restenosis

Postoperative embolic cerebrovascular complications and carotid restenosis were investigated to verify the efficacy of direct local application of argatroban. A cerebrovascular complication was defined as the occurrence of new signs or protracted aggravation of a preexisting neurological deficit. Postoperative carotid restenosis was defined as more than 50% stenosis on three-dimensional computed tomography angiography and B-mode ultrasonography. We assessed restenosis every 3 months during the first 6 months after CEA and every 6 months thereafter.

Data Analysis

Values presented in this study are expressed as mean ± standard deviation. One-way analysis of variance followed by post hoc Scheffé's test was used to determine the statistical significance of the differences among application durations. A P value of < 0.05 was considered statistically significant.

RESULTS

Tissue Level of Argatroban

Tissue levels of argatroban in the carotid plaque at 3, 5, and 10 minutes of direct application were 24.0 ± 13.7, 31.6 ± 20.0, and 44.0 ± 15.1 μg/g, respectively. Argatroban was undetectable (<0.5 μg/g) in all control tissues without argatroban application. The intraplaque concentration of argatroban increased proportional to the duration of application. The concentrations at all time points were significantly elevated compared with control ($P = 0.0022$, 0.0001, and <0.0001 at 3, 5, and 10 min, respectively). There was a significant difference in argatroban level between 3 minutes and 10 minutes ($P = 0.0112$). However, there was no significant difference in argatroban level between 3 minutes and 5 minutes. Furthermore, although a trend of increase was observed at 10 minutes of application compared with 5 minutes, the difference was not significant (*Fig. 2*).

Clinical Outcome

No patient developed postoperative cerebrovascular complications. However, postoperative carotid restenosis occurred in three patients (6.7%).

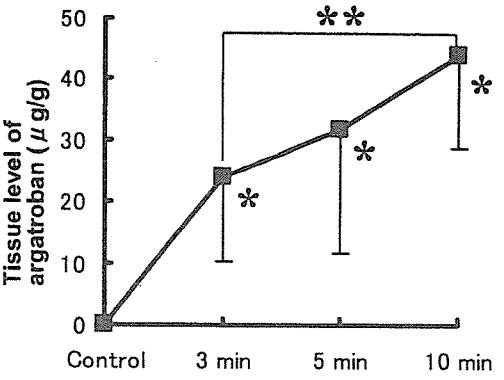

FIGURE 2. *Graph showing the tissue levels of argatroban (μg/g) by direct drug application for various durations during CEA. Data are mean ± standard deviation and were analyzed by one-way analysis of variance and then post hoc Scheffé's test. *, significant differences between control and each time point; **, significant difference between 3 minutes and 10 minutes.*

DISCUSSION

This is the first report of local tissue levels of argatroban after local application in humans. In the present study, the intraplaque concentrations of argatroban after direct application during CEA were elevated in a time dependent manner (*Fig. 2*). The levels at 3, 5, and 10 minutes of application were all significantly higher than the level in the control. Furthermore, the intraplaque concentration at 10 minutes was statistically elevated compared with that at 3 minutes. Even the concentration at 3 minutes was much higher than the effective tissue levels reported in a previous experimental study (8). These results suggest that direct application of argatroban delivers a high concentration of argatroban locally into vessel wall. The presence of drug within the plaque does not necessarily suggest that similar results will be observed in the residual artery wall after arteriotomy. However, we think that it is meaningful to assess tissue levels and clinical efficacy of argatroban simultaneously in the same patients. In humans, we cannot resect normal vascular wall after CEA to measure the tissue levels. Plaque tissue is the nearest resectable tissue that can be used to speculate regarding tissue level in the residual artery wall.

No patient developed postoperative cerebrovascular complications in the present series. Embolic ischemic complications have been reported to occur in approximately 2.6 to 6% of the patients after CEA (1, 12, 14, 19). Although the present investigation was not a controlled study, the results suggest that argatroban may be effective to prevent perioperative embolic cerebral complications. However, carotid restenosis occurred in three patients (6.7%). The reported incidence of carotid restenosis after CEA varies from 1.8 to 36%; this depends on the definition of restenosis (7, 16). A recent systematic review has demonstrated a 10% incidence of recurrent stenosis (≥50%) in the first year after CEA (6). Although locally delivered argatroban inhibited intimal thickening 20

days after balloon injury in animal models, as mentioned below (8), there was no long-term follow-up. In a comparison of the present results of recurrent carotid stenosis with those reported in the literature, single delivery of argatroban during surgery may not prevent restenosis in the chronic stage.

Two previous articles reported tissue argatroban levels after local delivery in experimental models (2, 8). In a newly developed catheter in porcine model, Anabuki et al. (2) demonstrated that the concentration of argatroban in the arterial wall at the coronary angioplasty site was significantly higher after local delivery. Furthermore, they demonstrated that high local concentrations (76.56 ± 30.74 μg/g) of argatroban did not damage vessel wall histologically (2). Imanishi et al. (8) evaluated the inhibitory effect of locally delivered argatroban on intimal proliferation after balloon injury of the carotid arteries in normal rabbits. In their study, the concentration of argatroban in the vessel wall was elevated sufficiently when a higher concentration (1 or 0.1 mg/ml) of argatroban solution was used (8). Furthermore, argatroban inhibited platelet aggregation, fibrin deposition, and intimal thickening 20 days after balloon injury (8).

In a previous investigation, concentration of argatroban after local administration via a hydrogel-coated balloon catheter immersed three times in an argatroban/saline solution was 14.8 ± 10.9 nmol/g (mean ± standard deviation, 7.79 ± 5.74 μg/g) (8). Argatroban at this tissue level significantly inhibited platelet deposition and chronic intimal thickening after balloon injury. Furthermore, much lower tissue concentration, i.e., 5.5 ± 4.6 nmol/g (mean ± standard deviation, 2.89 ± 2.42 μg/g) obtained from use of 0.1 mg/ml argatroban solution also achieved significantly smaller intimal-medial area ratios in the chronic stage compared with control (8). These tissue argatroban concentrations were much lower than the levels in the present study. Even the concentration after 3 minutes of application (24.0 ± 13.7 μg/g) in the present study was much higher than the reported effective levels. Extrapolating the above data, local application of argatroban for at least 3 minutes in accordance with the present protocol should be effective in preventing local mural thrombus formation, although there might be discrepancies in the effective tissue concentrations for inhibiting clot formation between humans and animals.

In animal models, local delivery of thrombin inhibitors has been reported to have significant effects in reducing platelet deposition and mural thrombus formation after balloon angioplasty or stent implantation, without influencing systemic coagulability compared with systemic administration of the drugs (11, 13, 20). To obtain the same local concentration as local delivery, much higher doses are needed for systemic administration. During CEA, we must prevent local mural thrombus formation after removal of the carotid plaque. Local application of argatroban just before closing the arteriotomy, in addition to the use of intraoperative systemic administration of heparin, should be an effective strategy.

Direct local application of argatroban during CEA for at least 3 minutes may deliver high local tissue levels. Argatroban may be effective in the prevention of perioperative embolic cerebral complications in CEA.

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COMMENTS

Kawamata et al. have performed a unique study in which they tested the safety of intraoperative, intraluminal, topically applied argatroban in the setting of carotid endarterectomy. High local tissue levels of this low-molecular-weight synthetic direct thrombin inhibitor were obtained with as little as 3 minutes of exposure in all 45 patients. Although the authors are careful to avoid claiming that use of this drug reduced the incidence of either thromboembolic events or restenosis, their data do suggest that at least in their hands, neither adverse event seemed to be increased. The next step is clearly a larger Phase I/II study. Such a study would do well to include other safety outcomes, such as the incidence of neck hematoma formation. The authors would probably do well to examine the effect of this drug on other surrogate markers of thromboembolism, such as intraoperative and early postoperative high-intensity transient analysis with transcranial Doppler ultrasound. It would also be interesting to see whether the incidence of neuropsychological dysfunction would be reduced by adding this agent as well.

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The authors report a study in which the synthetic thrombin inhibitor argatroban was applied during carotid endarterectomy. The drug was applied twice during surgery, initially before excision of the atherosclerotic plaque and again after endarterectomy and before closure. Varying drug exposure times were used, and plaque tissue levels of the drug were measured. A time-dependent relationship was found, with longer exposure times associated with higher tissue concentrations. The tissue concentrations found in this study are comparable to those found to inhibit platelet activation and thrombosis in experimental models. Local application of argatroban during carotid endarterectomy has the potential to be a relatively low-risk method to further reduce the risk of thromboembolic complications. Unfortunately, it is difficult to conclude that local tissue concentrations of the drug will translate into a reduction in thromboembolic risk. Furthermore, because the overall incidence of thromboembolic complications with carotid endarterectomy is relatively low, a randomized trial to assess this method would require a prohibitively large number of patients. Therefore, we are uncertain about the usefulness of this approach.

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Birmingham, Alabama
L. Nelson Hopkins
Buffalo, New York

Kawamata et al. have examined the topical application of argatroban, a direct thrombin inhibitor, immediately after arteriotomy and during closure of the arteriotomy in 45 patients undergoing carotid endarterectomy. They examined carotid plaque tissue levels of argatroban after the initial application and examined perioperative embolic complications and restenosis as surrogates of clinical efficacy.

Carotid plaque tissue levels of argatroban demonstrated an exposure-dependent increase after initial application. Indeed, an exposure time of 3 minutes (the shortest duration assessed) resulted in tissue levels of argatroban that far exceeded the effective tissue levels reported in experimental studies. There was no instance of cerebrovascular perioperative complications, and the restenosis rate was 6.7% (three patients).

This is an interesting and potentially useful application of this agent. The authors have convincingly demonstrated the ability to increase tissue levels in carotid plaques after topical application. However, the tissue levels in the residual vessel wall remain unknown. It is not unreasonable to assume that, particularly after the second application, tissue levels in the vessel wall will be increased.

The clinical effectiveness of this agent remains to be determined. The authors' preliminary perioperative complication rate is commendable; however, without a control group, these results cannot be ascribed to the use of argatroban. This will require further study. The authors do not report any complications of argatroban use, but do not specifically address whether local application of argatroban will influence systemic coagulation status. This is a difficult issue to address, because it is confounded by the use of systemic heparin, which is not reversed at the end of the procedure (thus prohibiting the use of early partial thromboplastin time as one coagulation parameter to assess). The chronic effects on restenosis of local application of argatroban after carotid endarterectomy also cannot be determined from this study. The duration of action after this type of application is unknown, and there is no control group to assess for a potential influence on restenosis rates.

The above notwithstanding, the authors have provided a meaningful contribution that documents preliminary experience with a potentially useful pharmacological adjunct during carotid endarterectomy that merits further study.

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Neal F. Kassell
Charlottesville, Virginia

In this article, the authors studied 45 patients undergoing carotid endarterectomy who received 5 mg of argatroban twice during carotid endarterectomy, once after arteriotomy, and they then measured intraplaque levels of the drug after application and then repeated the dose once during closure of the arteriotomy. The authors report that the carotid plaque revealed significant levels of the drug, which increased with exposure to the drug. They noted no clinical postoperative cerebrovascular complications and noted a 6.7% postoperative carotid restenosis rate of greater than 50%.

The authors' study actually raises as many questions as it seems to answer. The presence of drug within the plaque does not necessarily suggest that similar results will be seen in the residual artery wall after arteriotomy. The primary end point of

lack of embolic complications is followed only by clinical presentation rather than any measurement of emboli or studies for that. The restenosis rates are not well defined as to what period of time or what uniform studies were used to determine stenosis. It is not clear in the human what dose of drug one is trying to achieve in the residual wall, and this study does not answer that question any further. The duration of action of the drug over the entire period of reendothelialization of the endarterectomy site is also not clear. From this study, it is very difficult to imply efficacy of the agent. One would think that animal studies may be more pertinent for developing ideas of tissue levels with various dosing regimens. In the present protocol, one may not be certain that the presence of the agent within the plaque is also evidence for the presence of drug within the residual, presumably normal, wall.

Robert J. Dempsey
Madison, Wisconsin

脳卒中の外科 33: 335～341, 2005

特集　頸部頸動脈狭窄症の治療方針

頸部頸動脈狭窄病変に対する外科的治療指針
—現時点でのCEAの問題点と対策—

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Guidelines for Surgical Treatment of Cervical Carotid Stenotic Lesions

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Summary: We focused on complicated carotid lesions in 324 of our carotid endarterectomies (CEAs) to clarify controversies in carotid surgeries. Carotid lesions extented to the C_2 level in over 20% of lesions. Bilateral stenotic lesions were operated in 22 cases without problems. Nine of 15 contralateral occlusion cases were supported with STA-MCA anastomosis indicated by the CBF. In near-occlusion cases, distal sites of lesions were detected by IVUS. Restenosis was observed in 9 cases. Only 1 restenotic case was symptomatic and 4 restenotic cases were reoperated with patch graft. Hemashield patch grafts were used in 18 cases and no restenotic changes were observed. Intracranial aneurysm was seen in 12 cases and 7 cases were clipped before CEA. Hyperperfusion syndrome was seen in 6 cases. Two cases showed intracerebral hemorrhage resulting in postoperative neurological deficits. Symptomatic occlusive coronary lesions were seen in 62 cases and surgical or intravascular treatment or both were performed in 30 cases.
Guidelines for CEA have been established by randomized controlled trails, but some cases have very complicated clinical features such as multiple lesions. For these cases, safer and more effective strategies should be established by collaborative studies.

Key words:
- carotid occlusive lesion
- carotid endarterectomy
- multiple lesions

Surg Cereb Stroke (Jpn) 33: 335–341, 2005

はじめに

欧米における頸部頸動脈狭窄病変は，脳虚血発作，脳梗塞の主要な原因疾患として注目され，治療法として頸部狭窄病変を摘出する頸動脈血栓内膜剥離術(Carotid Endarterectomy: CEA)が多くの症例に施行されてきた．このCEAの有効性に関して国際的な共同研究が進められ，症候性と無症候性頸動脈狭窄病変の頸動脈写所見から内科的治療と外科的治療のRCT (randomized control trial)が行われ，外科治療選択のEBM (evidence based medicine)が

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確立されてきた[7)8)15)17)]．しかしこの国際共同研究のみですべての頸動脈病変に対処できるものではなくいまだ問題点が残されている．たとえば両側頸動脈病変，パッチグラフトの選択，脳動脈瘤を伴う頸動脈狭窄病変，閉塞性冠動脈病変を合併している症例などに対する指針があげられる．本邦においても脳虚血発作の原因として頸部頸動脈狭窄病変が注目されるようになり，CEA例も増加している．しかし本邦例では高位病変が多いことや頸部頸動脈が細いことなど欧米での症例と異なる点も知られている[21)]．これらの問題に関して324側の自験CEA症例からCEAの現状での問題点を検討した．

対象，方法

324側のCEA症例を対象とした．臨床像は，無症候性狭窄，transient ischemic attack (TIA)，reversible ischemic neurologic deficits (RIND)，minor completed stroke (MCS)で分類した．狭窄度は，脳血管写や3D-CTAからECST法で求めた．血流測定は，定量的なCold Xe-CT法，Xe^{133}-inhalation methodで施行した．

CEAは，以下のようにシャントシステムを用いて行った[19)]．症例は右頸部頸動脈に高度狭窄を認めた68歳男性である(Fig. 1A)．麻酔は，脳神経機能モニタリング(体性感覚誘発電位と運動誘発電位)を行うために筋弛緩剤を使用しないでpropofolとfentanylによる全身麻酔法を用いた．体位は，頭部を対側に20-30度回転し，胸鎖乳突筋の前縁を最も高くし，布テープで下顎先端部を挙上するように固定した．皮切は乳様突起から胸鎖乳突筋の前縁に沿って弧状に約7-8 cm行った．皮切に沿って広頸筋を切開し，carotid triangle内で頸動脈鞘に達し，狭窄病変のない位置で総頸動脈を確保した．この総頸動脈から末梢に向かって頸動脈の露出を進め，外頸動脈を確保し，次に内頸動脈を狭窄病変より末梢1-2 cmの位置で確保した．ヘパリン(3000-5000単位)を全身投与し，ACT(activated coagulation time)が200 sec以上としたのちに総頸，内頸，外頸動脈を遮断した．総頸動脈側から正常な内頸動脈部まで動脈を切開し，シャントチューブを装着した．総頸動脈側より内頸動脈側に向かって中膜と内膜の間で病変の剝離を進めた(Fig. 1C)．病変は，原則として一塊として摘出し，残ったdebrisを丁寧に除去した(Fig. 1D)．動脈切開部は，5-0プロリーン糸で連続縫合した．術後3D-CTアンギオグラフィーで狭窄病変の摘出を確認した(Fig. 1B)．

324側(298例)のCEAで以下のような点；(1) 病変の広がり，(2) 多発性病変(両側狭窄病変と対側閉塞病変)，(3) near-occlusion病変，(4) 脳動脈瘤を伴った病変，(5)

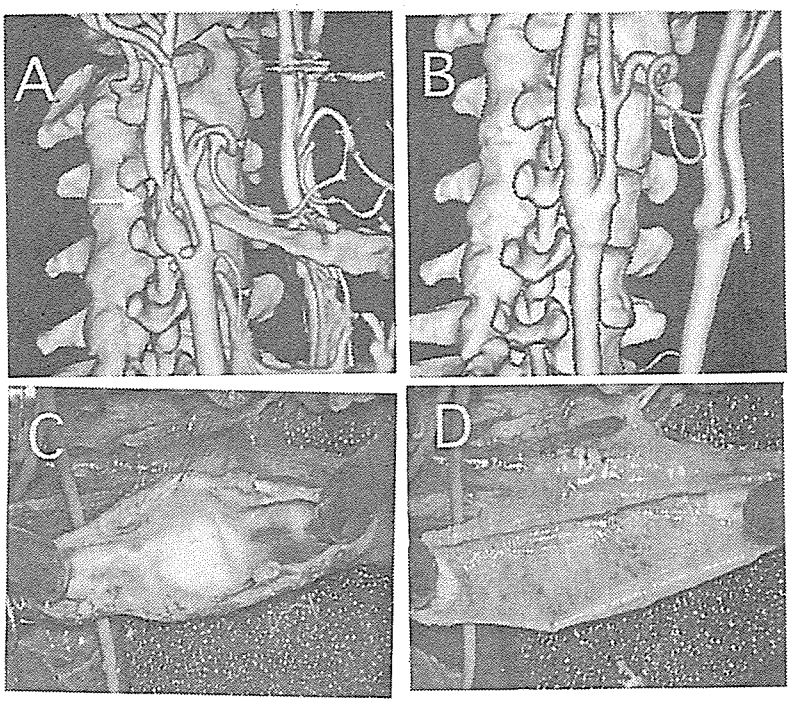

Fig. 1 Preoperative 3D-CT angiography demonstrates severe ICA stenosis (A). Postoperative 3D-CT angiography shows complete removal of the stenotic lesion (B). Intraoperative photographies show severe ICA stenosis with atheromatous plaque (C) and complete removal of the lesion (D).
3D-CT: 3 dimensional computed tomography, ICA: internal carotid artery

パッチグラフを要した病変，(6) 再狭窄病変，(7) 過還流症候群を呈した病変，(8) 心疾患について検討した．

結　果

298症例の性別は男性260例，女性38例で年齢は36-81(平均64)歳であった．324側頸動脈病変の臨床像は，無症候性狭窄102側，transient ischemic attack (TIA) 107側，reversible ischemic neurologic deficits (RIND) 42側，minor completed stroke (MCS) 73側であった．

病変の広がり：病変の広がりは脳血管写上での病変部の末梢側の位置で評価した．画像上末梢端の確認が困難であったnear-occlusion例を除いた317側の位置は，C2，C2/3，C3，C3/4，C4がそれぞれ51，37，168，26，35側であった．

多発性病変(両側狭窄病変と対側閉塞病変)：CEA症例に合併していた脳血管病変を**Table 1**にまとめた．多発性病変としては両側CEA施行例が22例で，対側に50%以上の狭窄病変を有しながらもCEAを施行しないで経過観察を行っていた症例が27例であった．対側内頸動脈閉塞例が12例，中大脳動脈閉塞例3例であった．これらのうち症候性で安静時血流量が20%以上低下し，ダイアモックス負荷テストで反応性が低下していた9症例ではSTA-MCA吻合術を施行したのちにCEAを行った．

near-occlusion病変：near-occlusionと判断した7症例にCEAを施行した．IVUS (intravascular ultrasound) カテーテルを血管外から使用する方法で病変の広がりを把握した．シャントチューブは全例問題なく装着できた．全例合併症なく十分な血行再建が得られた．

Table 1 Summary of complicated CEA cases with multiple lesions and restenotic changes

Bilateral ICA stenoses & CEAs	22 cases
Contralateral ICA occlusion	15 cases
(STA-MCA anastomosis	9 cases)
Contralateral stenosis>50%	27 cases
Near occlusion	7 cases
ICA stenosis & Cerebral aneurysm	10 cases
(Clipping	8 cases)
Restenosis	9 cases
(Reoperation	4 cases)

脳動脈瘤を伴った病変：CEA症例の12例に脳動脈瘤の合併を認め，8例にクリッピング術を施行した．CEA後に動脈瘤のクリッピング術を施行した症例は1例のみで，7例はクリッピング後にCEAを施行していた．

パッチグラフトを要した病変：パッチグラフトは，グラフトとしては足関節近傍から採取した静脈片かHemashieldを用いた．またパッチグラフトの適応は，繊維性狭窄病変例，内頸動脈の狭窄病変が3 cm以上にわたる例，再狭窄例とした．パッチグラフトは，シャントチューブをステントとして利用し連続縫合で行った(**Fig. 2**)．

静脈片を用いたパッチグラフトを15側，Hemashieldを用いたパッチグラフトを18側のCEAで施行していた．術後1年間の観察で静脈片を用いた1例で再狭窄を認めたが，Hemashieldを用いた症例では再狭窄は認められなかった．

再狭窄(1年以内での超音波検査で50%以上の狭窄)病

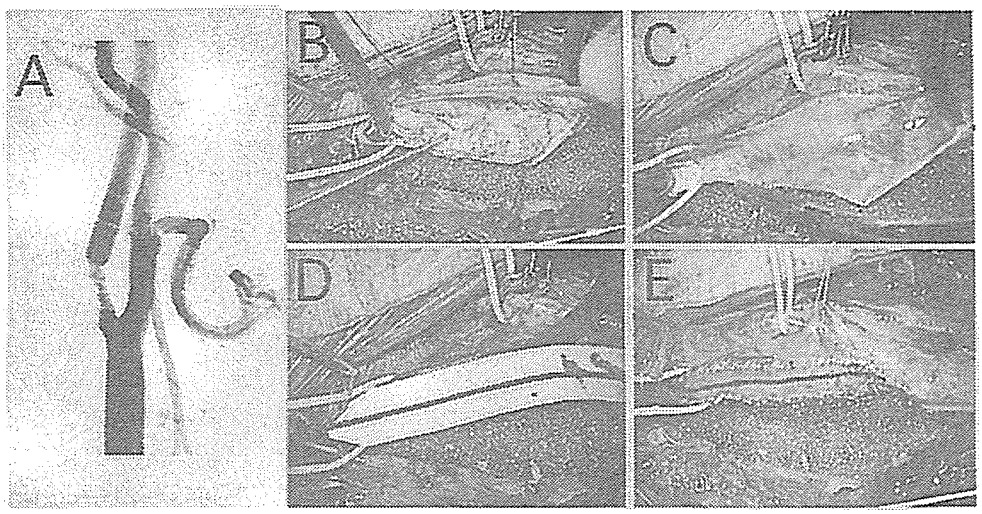

Fig. 2 Carotid angiography shows long segment severe stenosis of the ICA (A). The stenotic lesion is dissected using our shunt system (B). The stenotic lesion is removed completely (C). The size and shape of Hemashield patch graft is adjusted to the arteriotomy. (D). Arteriotomy is closed with Hemashield patch graft by running sutures (E).