



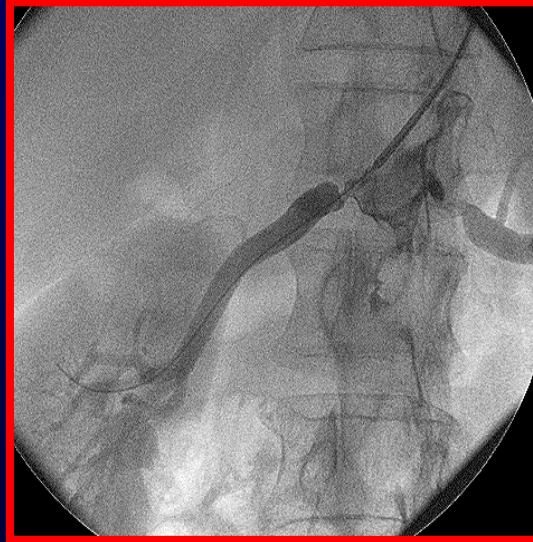
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## Ultraschall-Kriterien zur Beurteilung einer Nierenarterienstenose

# FDS nach Stent-PTRA ostialer NAS



**Beide NA  
90%**



**Multipurpose (7F)  
Führungsschleuse**



**Nach Corinthian  
Stent beidseits**

# *Renal Artery Stenting*

## *Introduction*

Atherosclerotic RAS may lead to :

- deterioration of a pre-existing primary hypertension
- reduction of kidney size and function --- ischemic nephropathy

# *Renal Artery Stenting Natural History (Atherosclerosis)*

132 RA, mean follow-up 32 months by CCDU  
Cumulative incidence of RAS-progression:

	<b>1 yr</b>	<b>2 yrs</b>	<b>3 yrs</b>
<b>normal to &gt;60%</b>	<b>0%</b>	<b>0%</b>	<b>8%</b>
<b>&lt;60% to &gt;60%</b>	<b>30%</b>	<b>44%</b>	<b>48%</b>
<b>&gt;60% to occlusion</b>	<b>4%</b>	<b>4%</b>	<b>8%</b>

# *Renal Artery Stenting Natural History (Atherosclerosis)*

Incidence of kidney atrophy within 2 years:

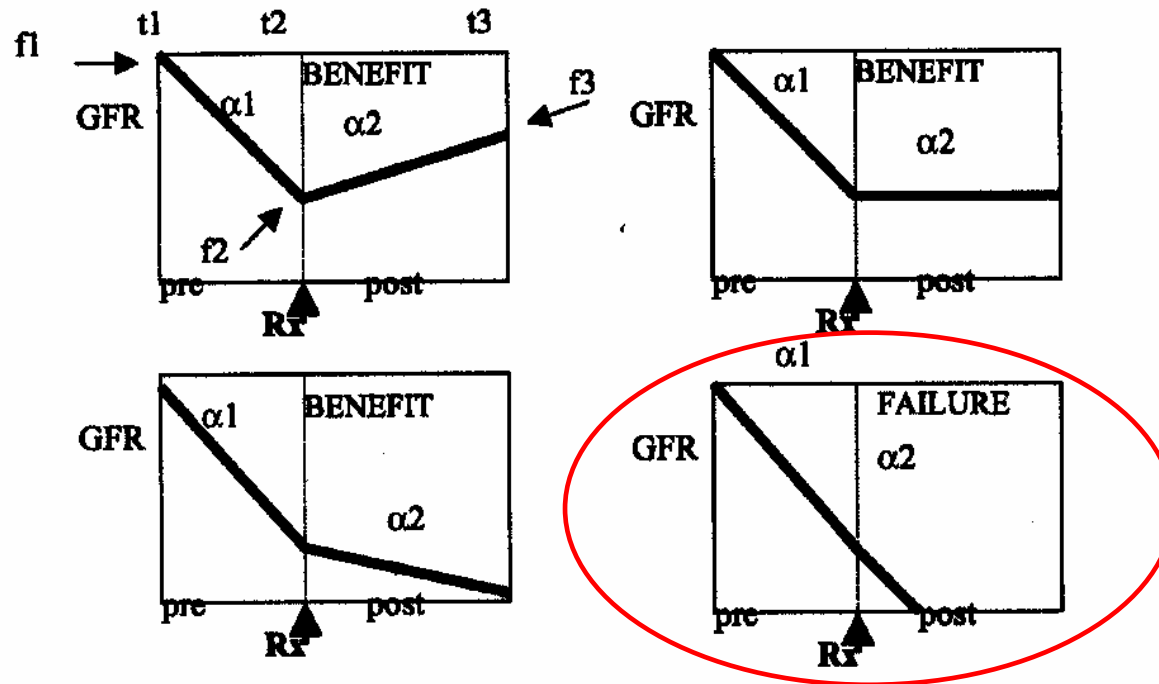
122 pts / 204 kidneys

Kidney atrophy : decrease of longitudinal diameter > 1cm

no RAS:	5%
< 60% RAS:	12%
> 60% RAS:	21%
BPs > 180mmHg:	35%
Vs > 400cm/s:	32%
Vendd < 5cm/s:	29%

Positive correlation of atrophy and increase of serum creatinine (p=0.03)

# Renal Artery Stenting Renal Function



Breakpoint analysis.  $\alpha_1$  indicates slope of GFR before treatment  $[(f_2 - f_1)/(t_2 - t_1)]$ ;  $\alpha_2$ , slope of GFR after intervention  $[(f_3 - f_2)/(t_3 - t_2)]$ ;  $\Delta\alpha$ , change in slope of GFR after treatment  $(\alpha_2 - \alpha_1)$ ;  $f_1$ , value of GFR at a definable time ( $t_1$ ) before intervention;  $f_2$ , value of GFR at the time of intervention ( $t_2$ ); and  $f_3$ , value of GFR at a definable follow-up time ( $t_3$ ).

# *Renal Artery Stenting*

## ***PTRA vs. Stent-PTRA in ostial RAS***

	<b>PTRA</b>	<b>sPTRA</b>
<b>Number of patients</b>	<b>42</b>	<b>43</b>
<b>Primary success rate</b>	<b>57%</b>	<b>88%</b>
<b>Primary patency rate</b>	<b>29%</b>	<b>75%</b>
<b>Restenosis rate</b>	<b>48%</b>	<b>14%</b>

# *Renal Artery Stenting Methods*

Single center registry

340 consecutively treated patients  
with  
456 renal artery stenoses  $\geq 70\%$

(mean FU  $34 \pm 20$  months)



# *Renal Artery Stenting Technical Results*

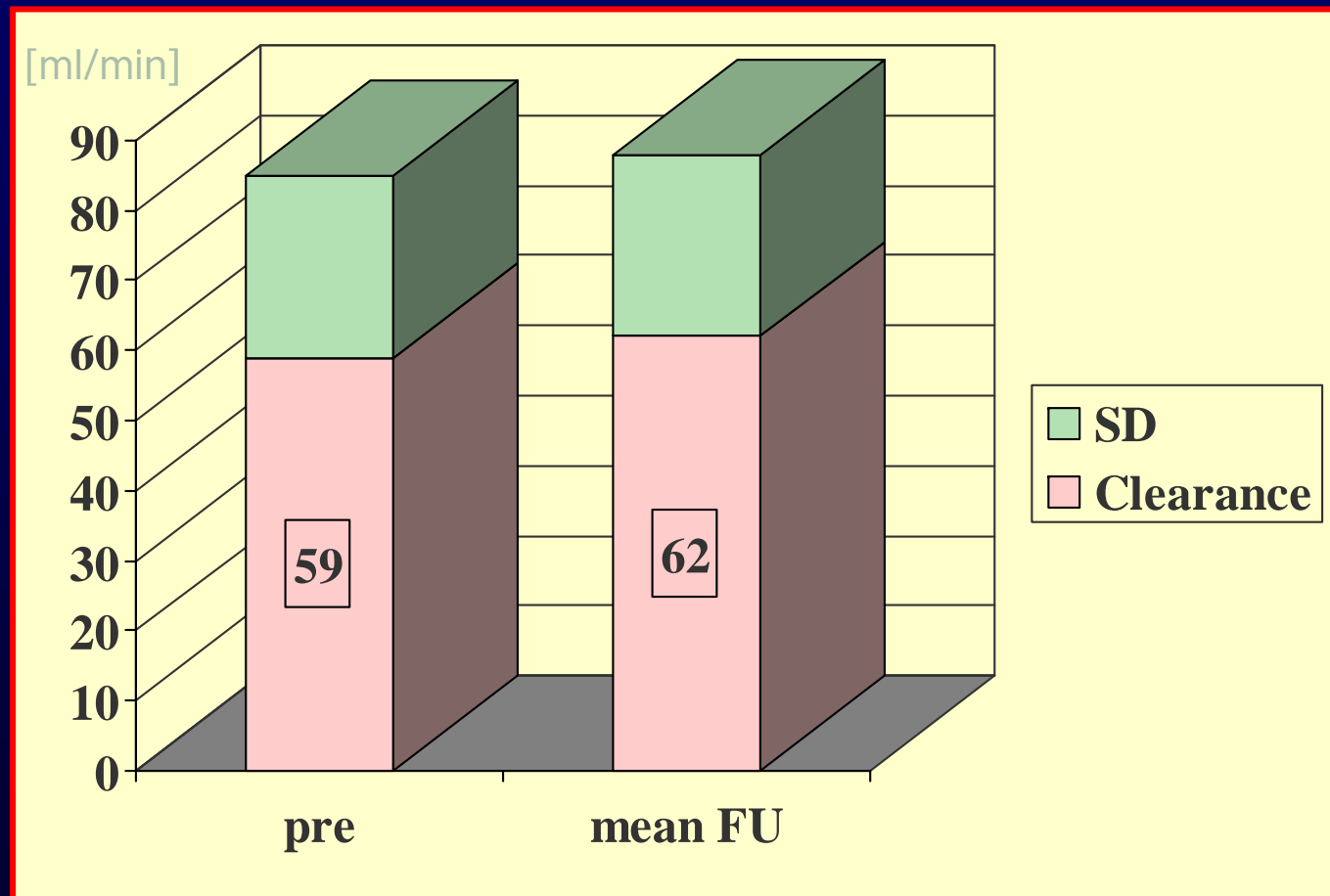
Initial technical success (ITS) stenoses:	100 %
ITS in chronic occlusions:	67 %
Mean stenosis reduction:	$83 \pm 9\%$ to $7 \pm 9\%$
Complication-rate:	8.5 %
Restenosis rate (mean FU):	10.2 %

# *Renal Artery Stenting Results – Renal Function*

## **Serum creatinine concentration:**

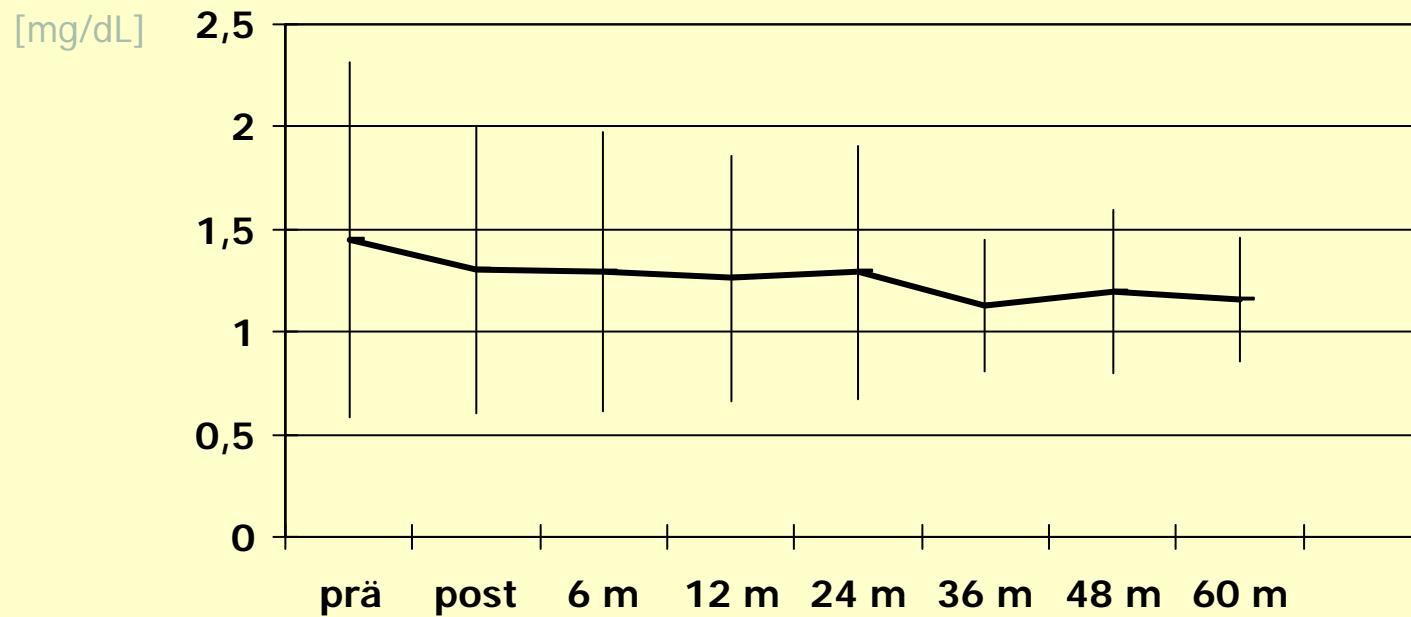
Decrease >10%:	34%
Unchanged:	39%
Increase > 10%:	27%

# *Renal Artery Stenting Results - Clearance*



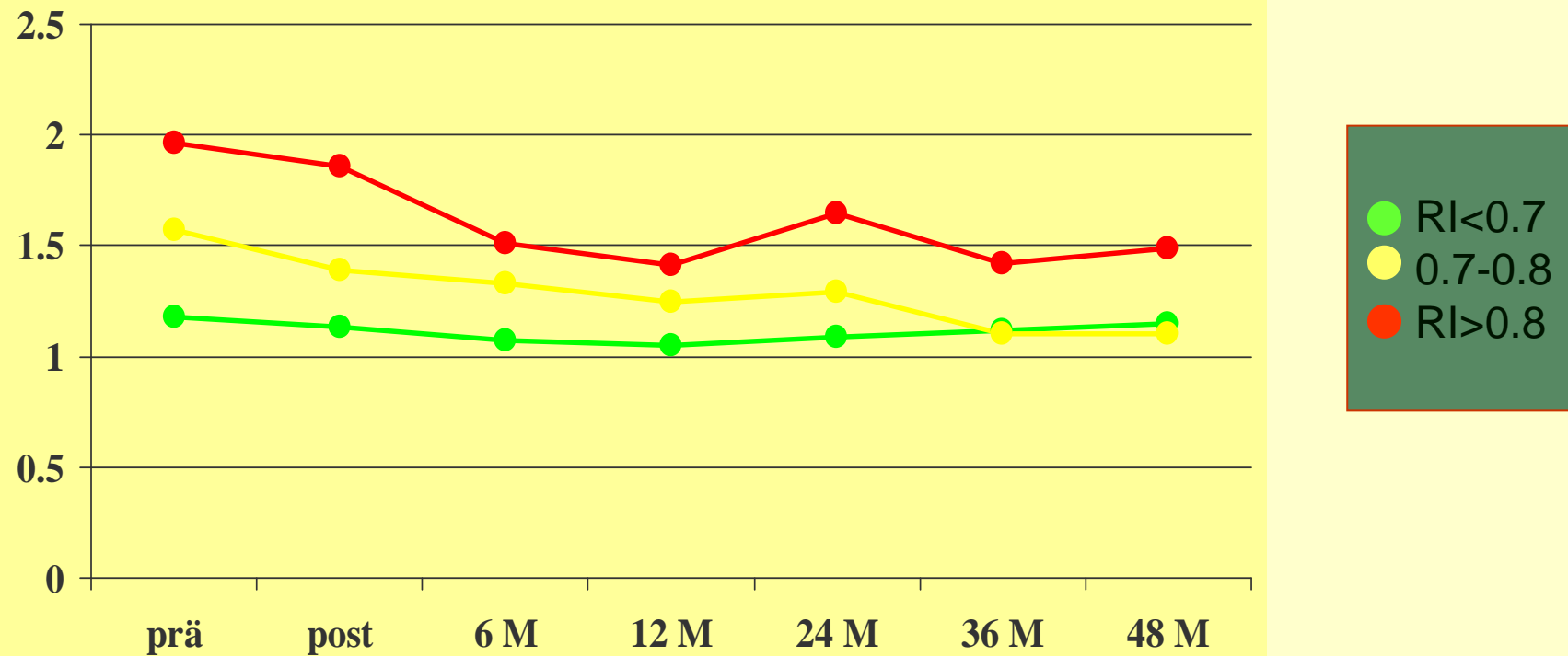
# *Renal Artery Stenting Results - Serum Creatinine*

## Serum-creatinine in follow up

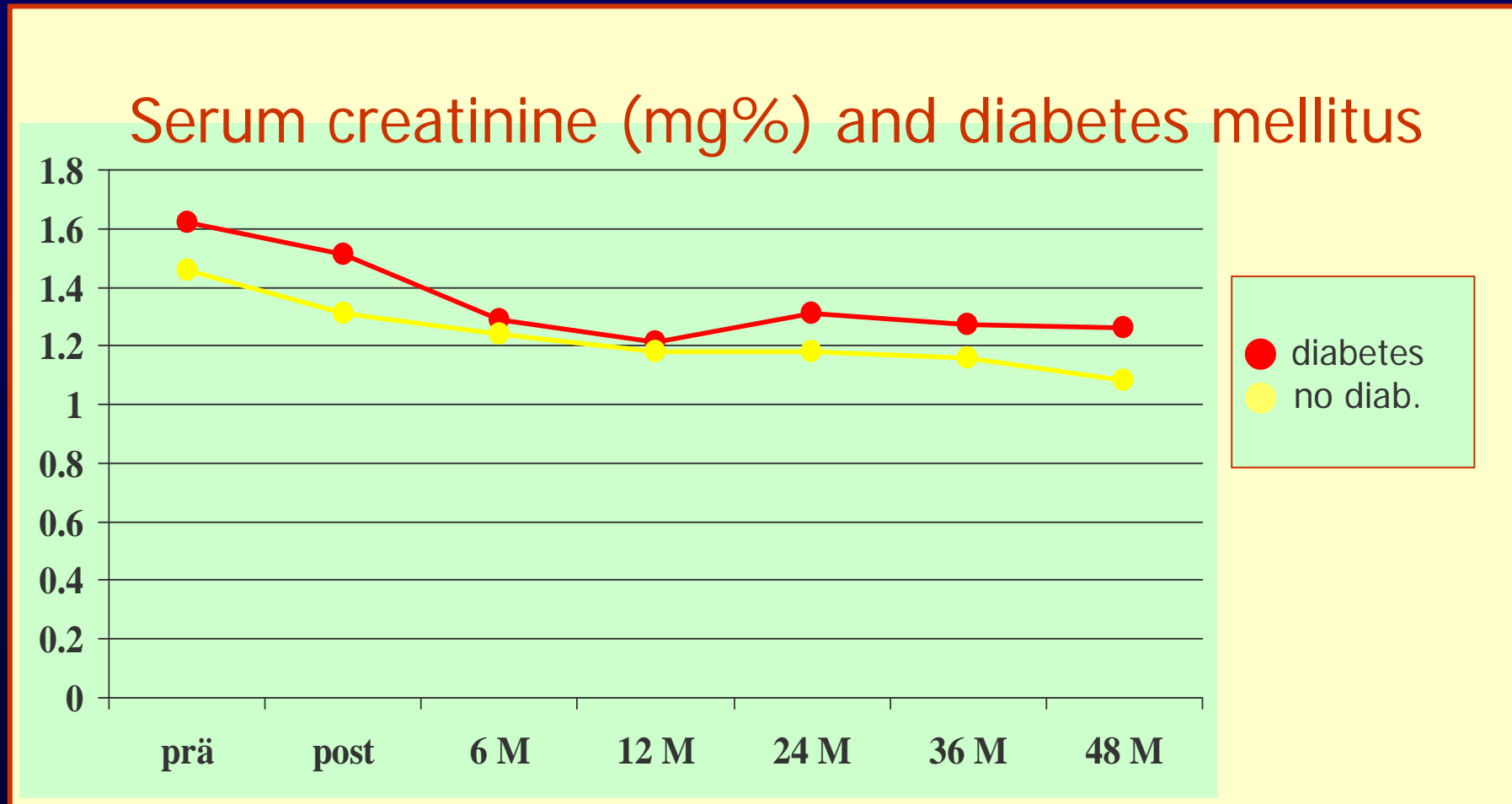


# *Renal Artery Stenting Results - Serum Creatinine*

Serum creatinine (mg%) and RI

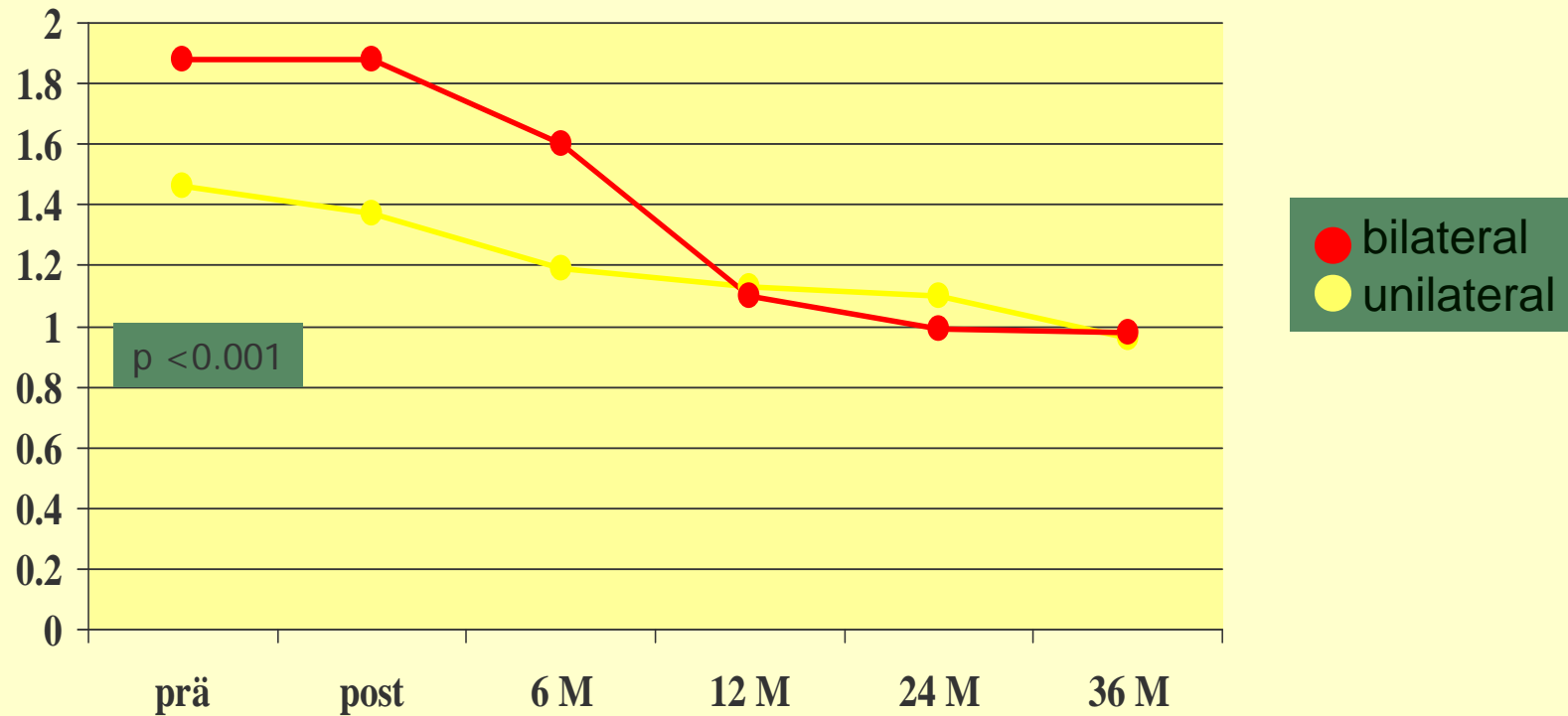


# *Renal Artery Stenting Results - Serum Creatinine*



# Renal Artery Stenting Results - Serum Creatinine

Serum creatinine (mg%) and RAS-localisation

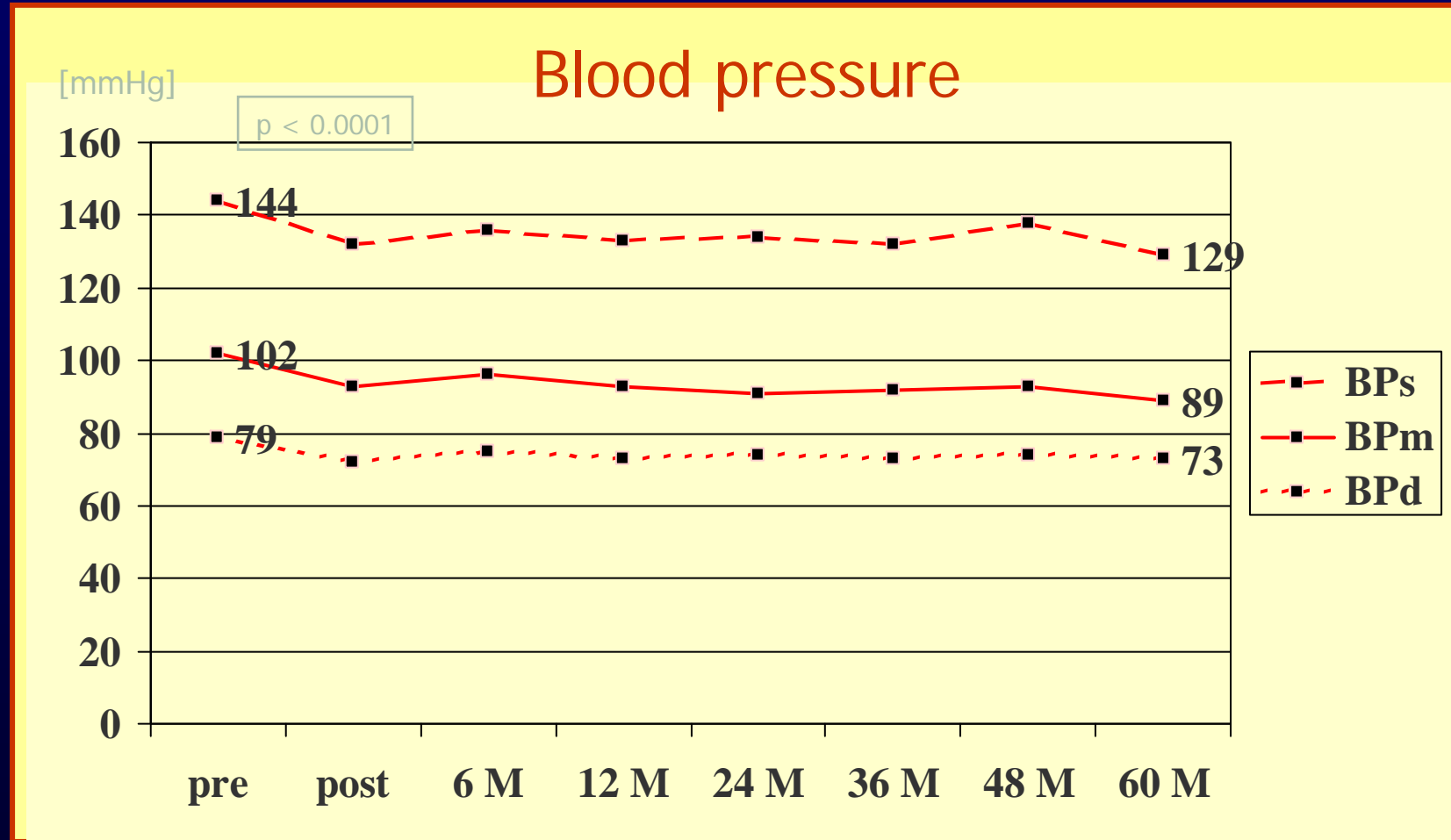


# *Renal Artery Stenting Results – Blood Pressure*

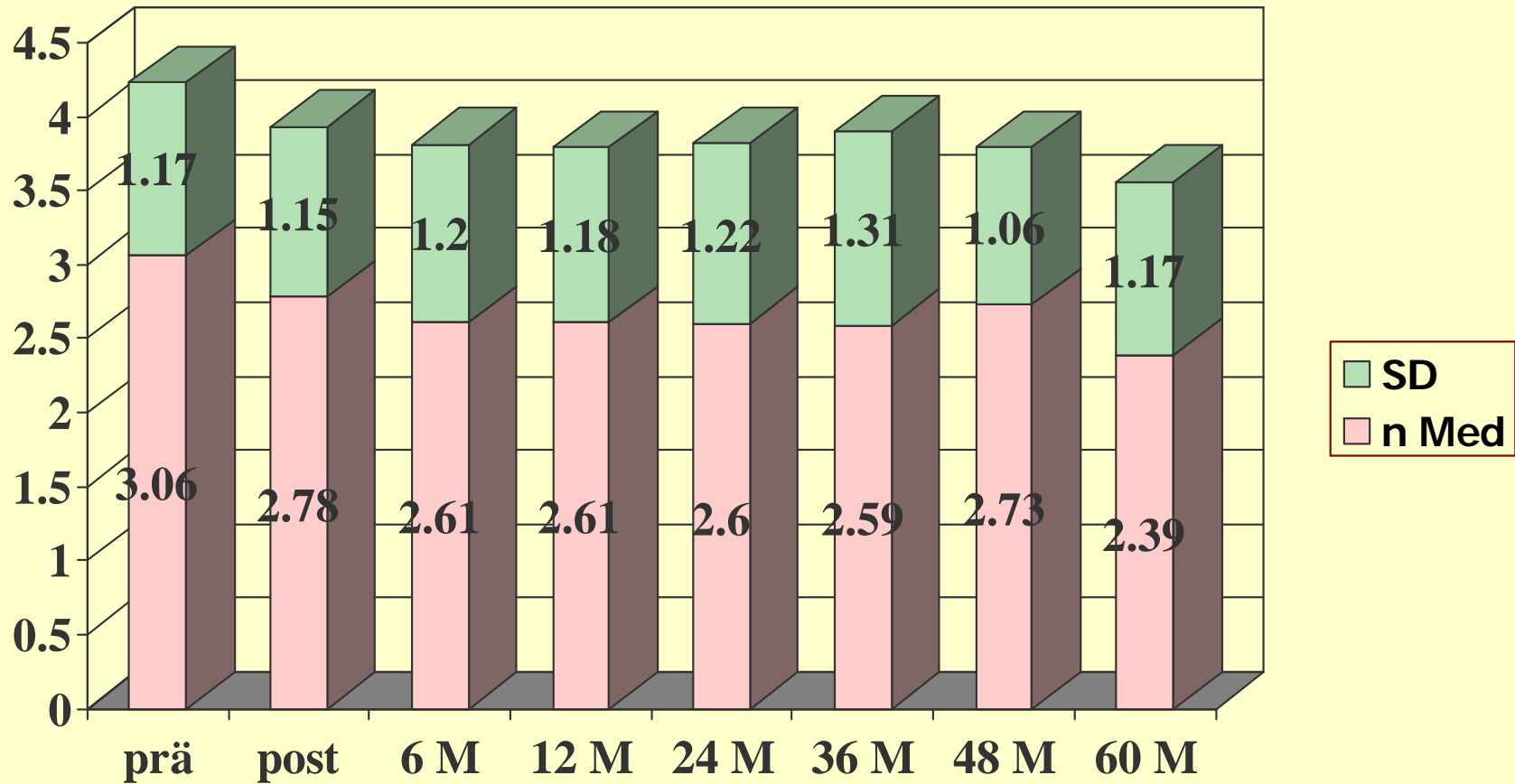
## **Blood pressure control:**

- Improved: 46%
- Unchanged: 43%
- Deteriorated: 11%

# Renal Artery Stenting Results – Blood Pressure



# Renal Artery Stenting Results – Medication



# *Renal Artery Stenting Results – Predictors of Success*

## **Blood pressure control:**

- Number of drugs taken at baseline

## **Renal function:**

- Baseline Serum creatinine concentration
- Bilateral intervention
- Percentage of diameter stenosis
- Coronary 3-vessel disease

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**Farbduplexsonographie zur Verlaufskontrolle nach  
Stent-PTRA ostialer Nierenarterienstenosen**

Retrospektive Analyse **500 konsekutiver**  
**FDS** bei Patienten mit arterieller Hypertonie

**Stenosekriterien:**

RAQ  $> 3,5$  und/oder

Seitendifferenz des RI  $> 0,05$

## FDS nach Stent-PTRA ostialer NAS

Darstellbarkeit von NA (1995-1997):

500 Patienten (2/3 nüchtern):

- Beide NA            448 Patienten (90%)
- Rechte NA            11 Patienten (2%)
- Linke NA             6 Patienten (1%)
- Keine NA            35 Patienten (7%)

## FDS nach Stent-PTRA ostialer NAS

**Bei 98 Pat. (19,6%) Hinweise auf NAS:**

**Bei 38 Pat. RAQ >3,5 + dRI >0,05:**

- NAS  $\geq$ 70%: 96%
- NAS 40-69%: 4%

**Spezifität: 97%**

**Sensitivität: 76%**

## FDS nach Stent-PTRA ostialer NAS

### Bei 54 Pat. RAQ > 3,5 aber dRI < 0,05:

- NAS  $\geq$ 70%: 24%
- NAS 40-69%: 68%
- NAS <40%: 8%

Spezifität: 60%

Sensitivität: 100%

### Kontrollgruppe (44 Pat. RAQ < 2,0 + dRI < 0,05):

- Keine NAS.

## FDS nach Stent-PTRA ostialer NAS Patienten und Methodik

Prospektive Studie bei 241 Pat. mit Stent-PTRA

- 355 atherosklerotischer ostialer NAS ( $\geq 70\%$ )

1292 Duplex Untersuchungen (1996-2001)

- Vor Intervention,
- Vor Entlassung,
- nach 6 and 12 Monaten,
- danach jährlich.

## FDS nach Stent-PTRA ostialer NAS

### Ergebnisse

- **RAQ berechenbar:** 98,9%  
(1278/1292 NA)
- **RI messbar:** 100%

# FDS nach Stent-PTRA ostialer NAS

## Ergebnisse

Effekt der Intervention:

- RAQ  $5,9 \pm 2,1 \longrightarrow 1,2 \pm 0,4$  ( $p < 0,00001$ )
- RI  $0,64 \pm 0,11 \longrightarrow 0,74 \pm 0,06$  ( $p < 0,00001$ )

RI der Gegenseite:  $0,74 \pm 0,07$

# FDS nach Stent-PTRA ostialer NAS

## RAQ/RI und Restenose

Nach mittlerem Follow-up von  $27 \pm 15$  Monaten:

- 37 Restenosen (10,4%)
- 12 Re-Restenosen
- 48 Reinterventionen + 1 iliaco-renaler Bypass

# FDS nach Stent-PTRA ostialer NAS

## RAQ/RI und Restenose

Duplex-Parameter bei Restenose:

**RAQ:**  $1,3 \pm 0,4 \longrightarrow 6,3 \pm 2,8$  ( $p < 0,001$ )

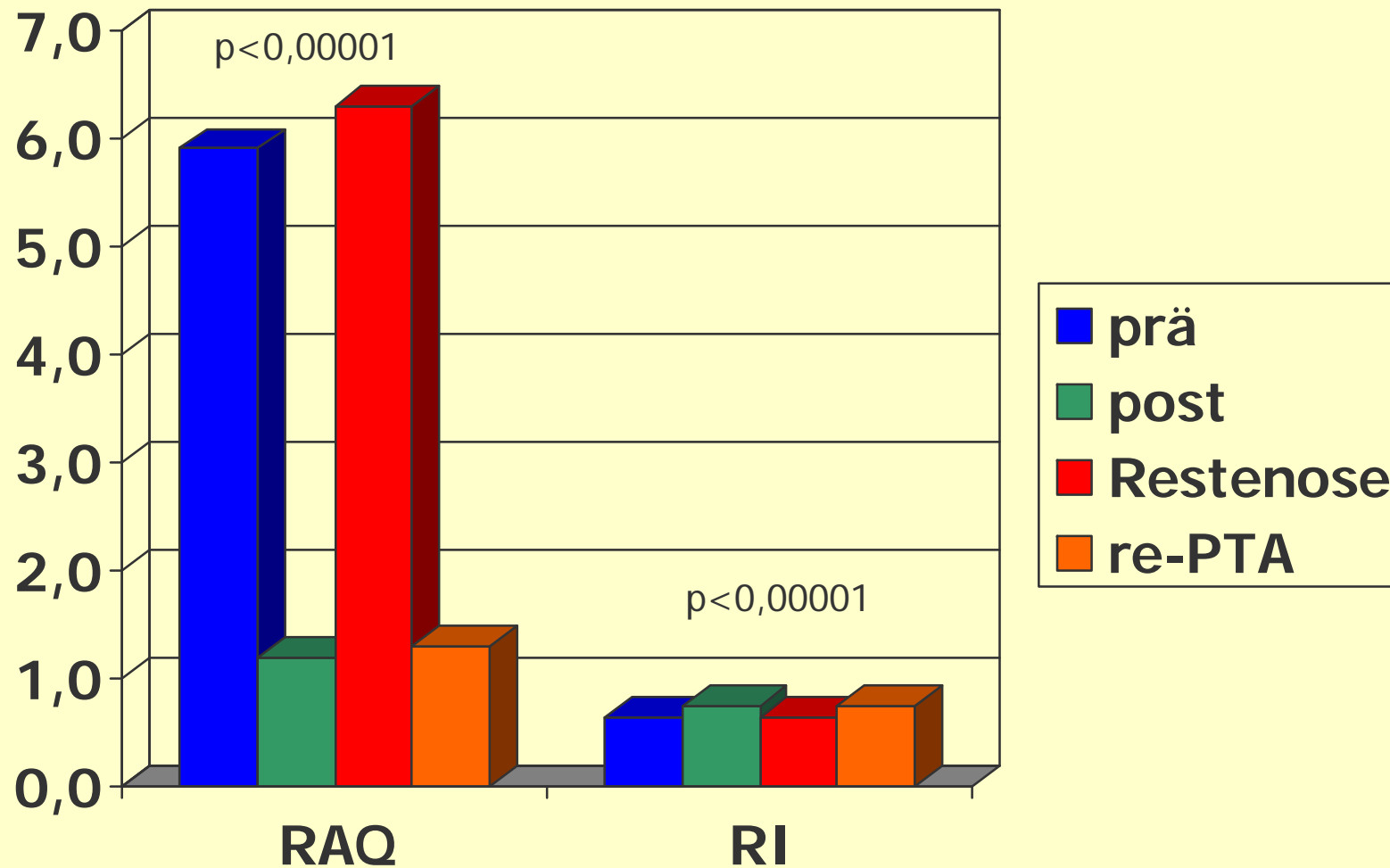
*Abfall* auf  $1,3 \pm 0,6$  nach Reintervention ( $p < 0,001$ )

**RI:**  $0,75 \pm 0,08 \longrightarrow 0,64 \pm 0,11$  ( $p < 0,001$ )

*Anstieg* auf  $0,75 \pm 0,07$  nach Reintervention ( $p < 0,001$ ).

# FDS nach Stent-PTRA ostialer NAS

## RAQ/RI bei Restenose

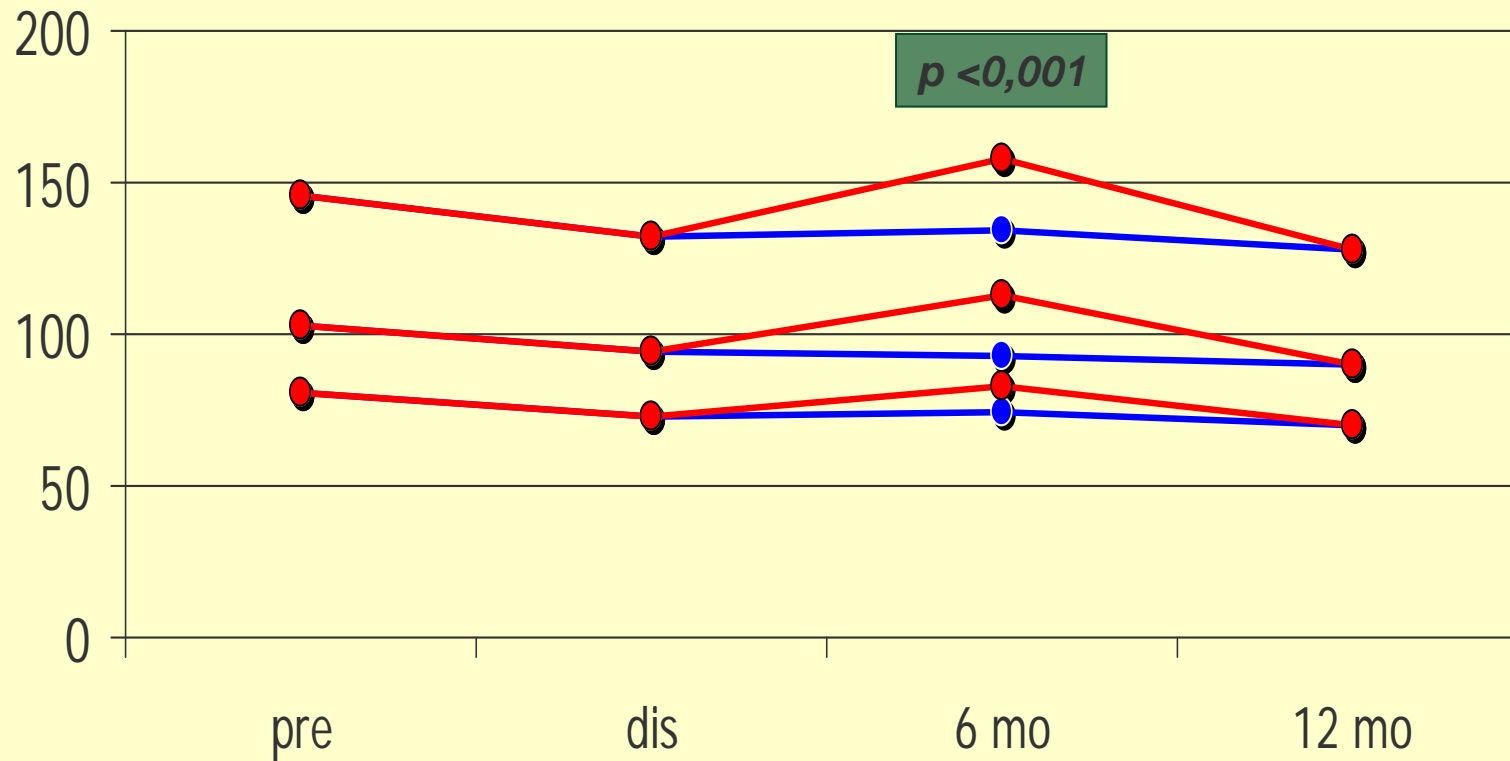


# FDS nach Stent-PTRA ostialer NAS

## Blutdruck bei Restenose

RR (mm Hg) bei Restenose

- keine Restenose
- Restenose



# Best Duplex-Sonographic Criteria for the Assessment of Renal Artery Stenosis – Correlation with Intra-Arterial Pressure Gradient

Beste duplexsonografische Kriterien zum Nachweis einer Nierenarterienstenose – Vergleich mit dem intraarteriellen Druckgradient

## Authors

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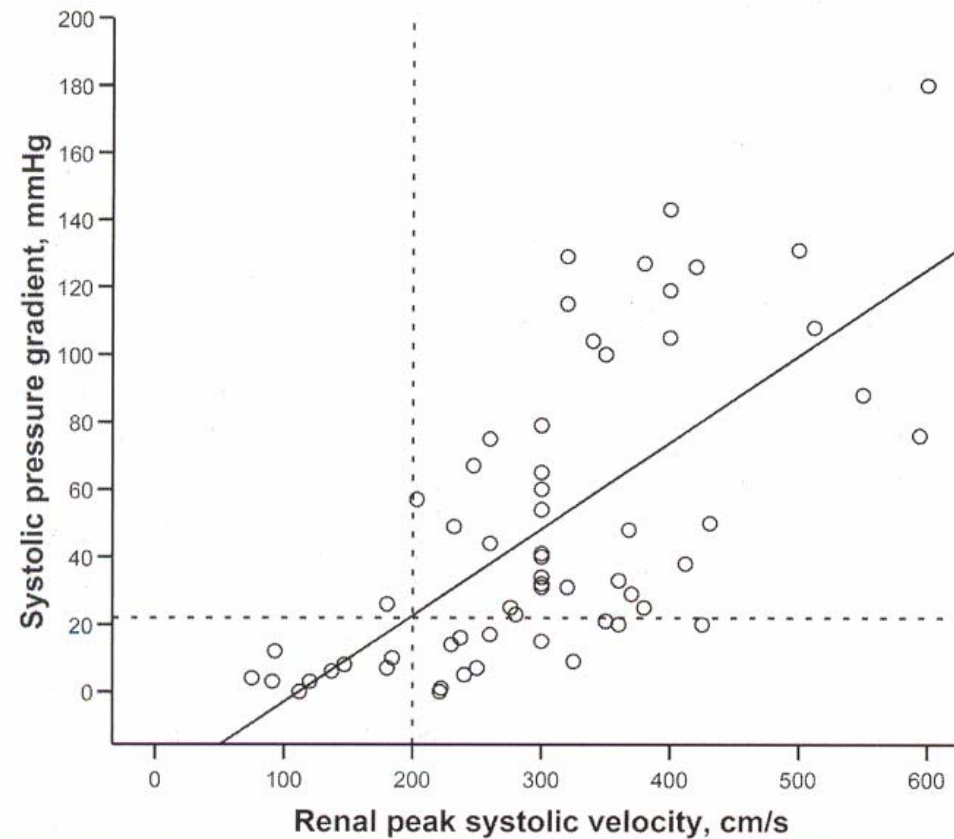
# Ergebnisse der Korrelation DUS / invasive Messung

	percent stenosis by renal arteriography			p-value <sup>2</sup>
	0–49% n = 39	50–69% n = 23	70–99% n = 31	
SPG, mmHg	5 (3–8)	24 (16–40)	88 (48–122)	< 0.001
PSV, cm/sec	135 (110–183)	276 (230–350)	355 (300–415)	< 0.001
EDV, cm/sec	40 (30–49)	81 (58–110)	120 (89–170)	< 0.001
RAR	1.7 (1.4–2.3)	3.7 (3.1–4.7)	4.6 (3.7–6.0)	< 0.001
Δ RI	–0.03 (–0.08–0.00)	0.01 (0.02–0.03)	0.02 (0.00–0.08)	< 0.001

**Table 1** Arteriographic and color coded duplex sonography results of 93 renal arteries<sup>1</sup>

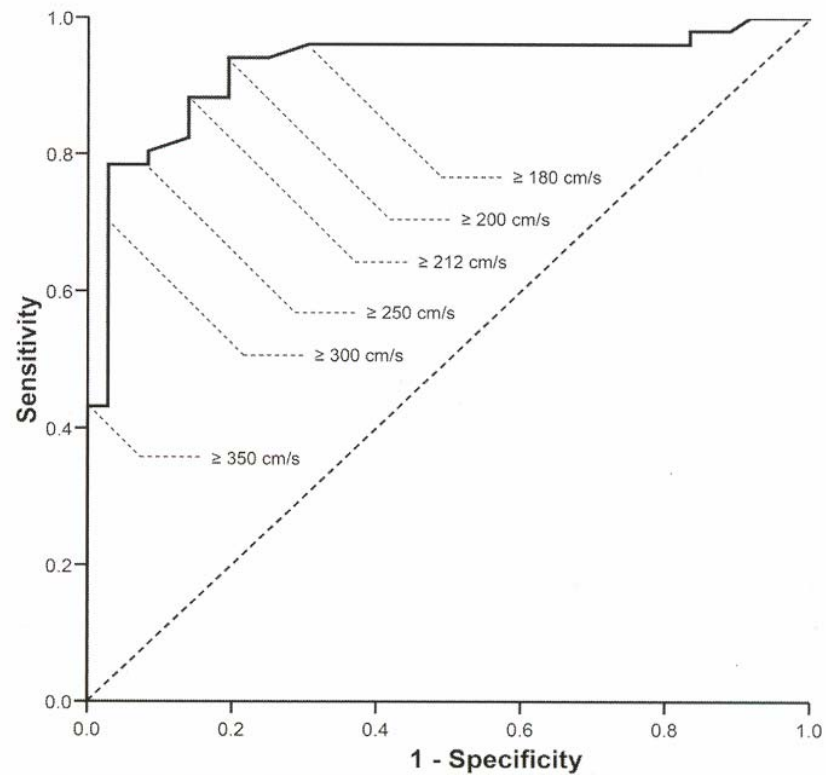
<sup>1</sup> Data are expressed as median (Interquartile range); SPG indicates intra-arterial systolic pressure gradient, PSV peak systolic velocity in the renal artery, EDV end-diastolic velocity in the renal artery, RAR renal/aortal ratio, and ΔRI side-to-side differences of the intrarenal resistive indices.

<sup>2</sup> p-value for trend (Kruskal-Wallis test)



**Fig. 2** Graph of a linear fit shows the correlation between pressure gradient and renal peak systolic velocity ( $r = 0.67$ ;  $p < 0.001$ ). Crosshairs show that 200 cm/sec indicates a mean gradient of 23 mmHg.

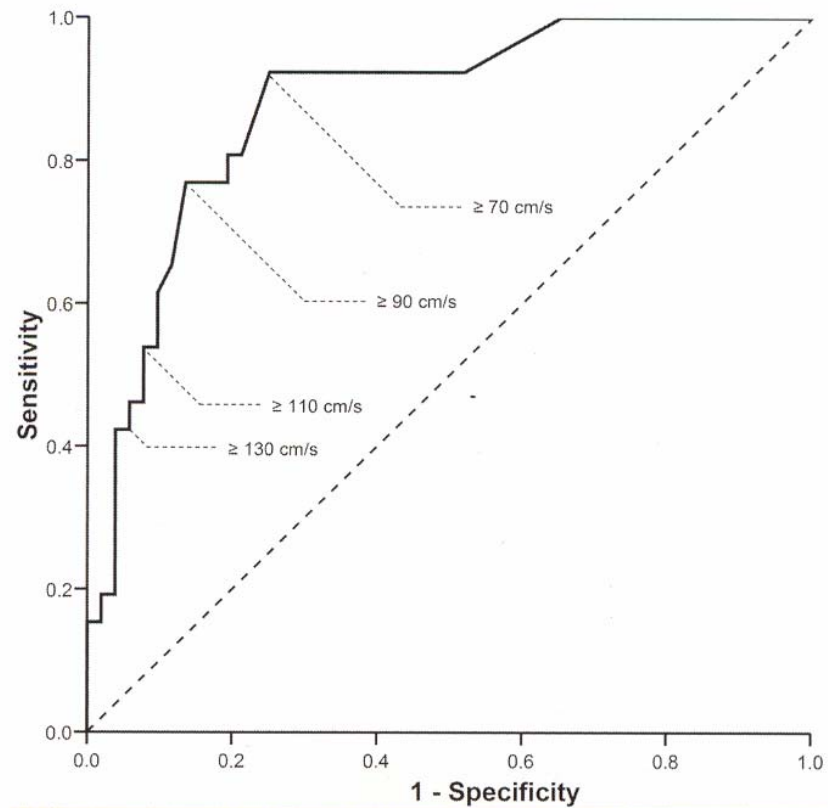
**Abb. 2** Lineare Korrelation zwischen dem Druckgradienten und der maximalen systolischen Geschwindigkeit in der Nierenarterie ( $r = 0,67$ ;  $p < 0,001$ ). Das Fadenkreuz zeigt, dass bei 200 cm/s ein mittlerer Gradient von 23 mmHg vorliegt.



**Fig. 3** Receiver operating characteristic (ROC) curves ( $n = 93$  renal arteries) showing sensitivity versus 1-specificity of a renal artery stenosis  $\geq 50\%$  for different peak systolic velocity (PSV) cut-off values. The area under the curve is 0.927 (95% CI 0.869–0.985;  $p < 0.001$ ).

**Abb. 3** Receiver-operating-characteristic-(ROC)-Kurven ( $n = 93$  Nierenarterien) für Nierenarterienstenose  $\geq 50\%$  mit Darstellung der Sensitivität versus 1-Spezifität für verschiedene Grenzwerte der maximalen systolischen Geschwindigkeit (PSV). Die Fläche unter der Kurve beträgt 0,927 (95% CI 0,869–0,985;  $p < 0,001$ ).

Kriterien für  
>50 % RAS



**Fig. 4** Receiver operating characteristic (ROC) curves (n = 93 renal arteries) showing sensitivity versus 1-specificity of a renal artery stenosis  $\geq 70\%$  for different end-diastolic velocity (EDV) cut-off values. The area under the curve is 0.877 (95% CI 0.798–0.957;  $p < 0.001$ ).

**Abb. 4** Receiver-operating-characteristic-(ROC)-Kurven (n = 93 Nierenarterien) für Nierenarterienstenose  $\geq 70\%$  mit Darstellung der Sensitivität versus 1-Spezifität für verschiedene Grenzwerte der end-diastolischen Geschwindigkeit (EDV). Die Fläche unter der Kurve beträgt 0,877 (95% CI 0,798–0,957;  $p < 0,001$ ).

Kriterien für  
> 70 % RAS

**Table 2** Diagnostic performance of color coded duplex sonography criteria for the detection of renal artery stenosis  $\geq 50\%$ <sup>1</sup>

	sensitivity %	specificity %	positive predic- tive value %	negative predic- tive value %	accuracy %	positive likelihood ratio	negative likelihood ratio
<i>PSV, cm/sec</i>							
$\geq 180$	96	69	81	93	85	3.10	0.06
$\geq 200$	92	81	87	88	87	4.84	0.10
$\geq 250$	78	92	93	75	84	9.75	0.24
$\geq 300$	69	97	97	68	80	23.00	0.32
$\geq 350$	41	100	100	55	66	> 23.00	0.59
<i>RAR</i>							
$\geq 2.0$	96	59	77	91	80	2.34	0.07
$\geq 2.5$	92	79	86	87	87	4.38	0.10
$\geq 3.0$	83	91	93	80	87	9.22	0.19
$\geq 3.5$	75	97	97	73	84	25.00	0.26
$\geq 4.0$	48	97	96	57	68	16.00	0.54
<i><math>\Delta RI</math></i>							
$\geq 0.01$	58	88	87	60	71	4.83	0.48
$\geq 0.02$	56	88	87	59	70	4.67	0.50
$\geq 0.03$	42	91	87	53	62	4.67	0.64
$\geq 0.04$	31	94	88	49	57	5.17	0.73
$\geq 0.05$	31	97	93	50	58	10.33	0.71

<sup>1</sup> PSV indicates peak systolic velocity in the renal artery, RAR renal/aortal ratio, and  $\Delta RI$  side to side difference of intrarenal resistive index.

**Table 3** Diagnostic performance of color coded duplex sonography criteria for the detection of renal artery stenosis  $\geq 70\%$ <sup>1</sup>

	sensitivity %	specificity %	positive predic- tive value %	negative predic- tive value %	accuracy %	positive likelihood ratio	negative likelihood ratio
<i>PSV, cm/sec</i>							
$\geq 200$	100	56	52	100	70	2.27	< 0.01
$\geq 250$	89	70	58	93	76	2.97	0.16
$\geq 300$	89	81	69	94	84	4.68	0.14
$\geq 350$	54	90	71	80	78	5.40	0.51
$\geq 400$	36	97	83	76	77	12.00	0.66
<i>EDV, cm/sec</i>							
$\geq 70$	92	73	63	95	79	3.40	0.11
$\geq 90$	77	87	74	88	83	5.92	0.26
$\geq 110$	54	90	74	80	78	5.40	0.51
$\geq 130$	46	92	75	77	77	5.75	0.59
$\geq 150$	35	96	82	75	76	8.75	0.68
<i>RAR</i>							
$\geq 2.5$	100	54	49	100	68	2.17	< 0.01
$\geq 3.0$	88	63	51	92	71	2.38	0.19
$\geq 3.5$	84	72	57	91	76	3.00	0.22
$\geq 4.0$	60	84	63	83	77	3.75	0.48
$\geq 4.5$	52	88	65	81	77	4.33	0.55
<i><math>\Delta RI</math></i>							
$\geq 0.03$	46	80	52	76	70	2.30	0.68
$\geq 0.04$	42	89	65	77	74	3.82	0.65
$\geq 0.05$	42	91	69	77	76	4.67	0.64
$\geq 0.06$	39	91	67	76	74	4.33	0.67
$\geq 0.07$	35	95	75	76	76	7.00	0.68

<sup>1</sup> PSV indicates peak systolic velocity in the renal artery, EDV end-diastolic velocity, RAR renal/aortal ratio, and  $\Delta RI$  side to side difference of intrarenal resistive index.

# Praktischer Untersuchungsleitfaden

Bestimmung Aortenflussgeschwindigkeit \*

Ableitung Nierenarterienabgänge bds \*

Bestimmung Nierengrösse  
(fokale Parenchymverschräkung?)

Ableitung 3 x Parenchymflüsse \*\*  
(Mark-Rindengrenze: Oberpol, Mitte, Unterpol)

\*Dopplerwinkel < 60 Grad  
Höhe Nierenarterienabgang  
\*\* 3 Zyklen ableiten

## Beurteilungskriterien

RAQ < 3.5 und RI seitengleich --- keine NAST

RAQ einseitig  $\geq 3.5$  aber RI seitengleich --- mittelgradige NAST \*

RAQ einseitig  $\geq 3.5$  und RI Differenz  $\geq 0.05$  – hochgradige NAST \*\*

\*Verlaufskontrolle in 6-12 Mon.

\*\* Angio in PTRR-Bereitschaft

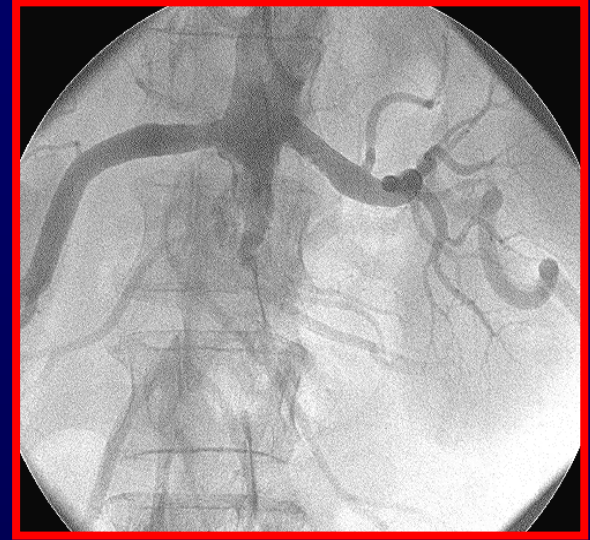
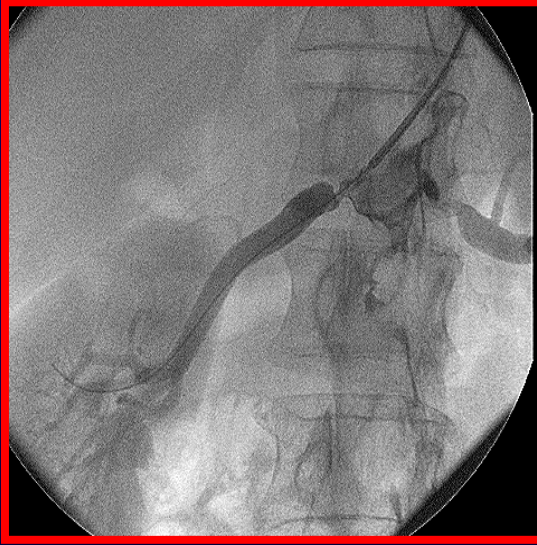
## Beurteilungskriterien

RAQ bds  $\geq 3.5$  und RI seitengleich ---  
bds. mindestens mittelgradige NAST \*\*

RAQ bds  $\geq 3.5$  und RI different ---  
Seite mit niedrigerem RI hochgradige Stenose,  
Seite mit höherem RI mindestens mittelgradige NAST\*\*

\*Verlaufskontrolle in 6-12 Mon.

\*\* Angio in PTRÄ-Bereitschaft



**Vielen Dank**

