

## Post-Carotid Endarterectomy Hypertension. Part 1: Association with Pre-operative Clinical, Imaging, and Physiological Parameters

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### WHAT THIS PAPER ADDS

This is one of the largest prospective studies to evaluate a battery of pre-operative clinical and non-invasive peripheral/central haemodynamic measurements, with the aim of identifying factors that were predictive of patients requiring treatment for post-carotid endarterectomy (CEA) hypertension. This study showed that patients requiring treatment for post-CEA hypertension had significantly higher pre-operative blood pressure (BP) and pre-existing, impaired baroreceptor sensitivity. By contrast, pre-operative BP lability, stenosis severity, bilateral disease, all other clinical parameters, and impaired cerebral autoregulation were not associated with post-endarterectomy hypertension.

**Objective/Background:** Post-endarterectomy hypertension (PEH) is a well recognised, but poorly understood, phenomenon after carotid endarterectomy (CEA) that is associated with post-operative intracranial haemorrhage, hyperperfusion syndrome, and cardiac complications. The aim of the current study was to identify pre-operative clinical, imaging, and physiological parameters associated with PEH.

**Methods:** In total, 106 CEA patients undergoing CEA under general anaesthesia underwent pre-operative evaluation of 24 hour ambulatory arterial blood pressure (BP), baroreceptor sensitivity, cerebral autoregulation, and transcranial Doppler measurement of cerebral blood flow velocity (CBFv) and pulsatility index. Patients who met pre-existing criteria for treating PEH after CEA (systolic BP [SBP] > 170 mmHg without symptoms or SBP > 160 mmHg with headache/seizure/neurological deficit) were treated according to a previously established protocol.

**Results:** In total, 40/106 patients (38%) required treatment for PEH at some stage following CEA (26 in theatre recovery [25%], 27 while on the vascular surgical ward [25%]), while seven (7%) had SBP surges > 200 mmHg back on the ward. Patients requiring treatment for PEH had a significantly higher pre-operative SBP ( $144 \pm 11$  mmHg vs.  $135 \pm 13$  mmHg;  $p < .001$ ) and evidence of pre-existing impairment of baroreceptor sensitivity ( $3.4 \pm 1.7$  ms/mmHg vs.  $5.3 \pm 2.8$  ms/mmHg;  $p = .02$ ). However, PEH was not associated with any other pre-operative clinical features, CBFv, or impaired cerebral haemodynamics. Paradoxically, autoregulation was better preserved in patients with PEH. All four cases of hyperperfusion associated symptoms were preceded by PEH. Length of hospital stay was significantly increased in patients with PEH ( $p < .001$ ).

**Conclusion:** In this study, where all patients underwent CEA under general anaesthesia, PEH was associated with poorly controlled pre-operative BP and impaired baroreceptor sensitivity, but not with other peripheral or central haemodynamic parameters, including impaired cerebral autoregulation.

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### INTRODUCTION

Carotid endarterectomy (CEA) is of proven benefit in treating selected patients with carotid artery disease,<sup>1–3</sup>

despite carrying a small, but important, risk of peri-operative stroke. Over the last two decades, the Leicester group has systematically investigated the main causes of peri-operative stroke, in order to implement and audit strategies for its prevention.<sup>4</sup> Intra-operative transcranial Doppler (TCD) monitoring and completion angiography virtually abolished intra-operative stroke, while selective Dextran therapy (later superseded by pre-operative dual antiplatelet therapy) prevented early post-operative

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**Table 1.** Incidence of post-carotid endarterectomy hypertension and neurological deficit.

Reference	P/R	Definition of pre-operative hypertension	Definition of post-operative hypertension	Patients with pre-operative hypertension (n)	Patients with post-operative hypertension (n)	Preoperative + post-operative hypertension (n)	Neurological complications	
							Normotensive group	Hypertensive group
Lehv et al. (1970) <sup>5</sup>	R	ND	Sustained > 15 mmHg rise in MAP above pre-operative BP	18/27 (67%)	15/27 (56%)	—	0/12 (0%)	7/15 (47%; <i>p</i> = .005)
Bove et al. (1979) <sup>6</sup>	P	ND	> 40 mmHg rise in SBP above pre-operative BP	—	19/100 (19%)	—	0/53 (0%)	2/19 (11%)
Towne and Bernhard (1980) <sup>7</sup>	R	BP > 150/90 mmHg	SBP > 200 mmHg	156/253 (62%)	49/253 (19%)	39/49 (80%; <i>p</i> < .01)	7/204 (3%)	5/49 (10%; <i>p</i> < .005)
Davies and Cronin (1980) <sup>7</sup>	P	SBP > 160 mmHg/DBP > 100 mmHg	SBP > 160 mmHg or DBP > 100 mmHg	19/42 (45%)	28/42 (67%)	13/28 (46%)	0/42 (0%)	9/42 (21%; <i>p</i> < .004)
Skudlarick and Mooring (1982) <sup>9</sup>	P	ND	SBP > 150 mmHg	24/41 (59%)	26/41 (63%)	19/26 (73%)	0/41 (0%)	0/41 (0%)
Asiddao et al. (1982) <sup>10</sup>	R	Controlled SBP < 170 mmHg Uncontrolled SBP > 170 mmHg <sup>a</sup>	SBP > 200 mmHg or DBP > 110 mmHg	79/166 (48%) <sup>b</sup> 21/166 (13%) <sup>c</sup>	50/166 (30%)	28/79 (35%; <i>p</i> < .05) <sup>b</sup> 11/21 (52%; <i>p</i> < .01) <sup>c</sup>	3/66 (4.5%)	6/79 (8%) <sup>b</sup> 7/21 (33%; <i>p</i> < .005) <sup>c</sup>
Englund and Dean (1986) <sup>11</sup>	P	DBP > 100 mmHg	DBP > 100 mmHg	33/100 (33%)	37/100 (37%)	26/33 (79%)	0/63 (0%)	2/37 (5%) <sup>d</sup>
Skydell et al. (1987) <sup>12</sup>	R	ND	> 35 mmHg rise in SBP above pre-operative	62/100 (62%)	58/100 (58%)	—	0/100 (0%)	2/100 (2%)
Benzel and Hoppens (1991) <sup>13</sup>	R	Normotension (< 170 mmHg SBP) Controlled (< 170 mmHg SBP + medicated) Uncontrolled (> 170 SBP mmHg)	SBP > 200 mmHg and DBP > 100 mmHg	45/100 (45%) <sup>b</sup> 13/100 (13%) <sup>c</sup>	35/100 (35%)	19/45 (42%; <i>p</i> < .05) <sup>b</sup> 7/13 (54%; <i>p</i> < .05) <sup>c</sup>	1/65 (2%) <sup>e</sup>	1/35 (3%) <sup>f</sup>
Hans and Glover (1995) <sup>14</sup>	P	BP > 150/90 mmHg	SBP > 180 mmHg and > 35 mmHg rise in SBP/DBP > 100 mmHg and > 20 mmHg rise in DBP/elevated BP requiring medication	—	214/330 (65%)	—	1/116 (1%)	10/214 (5%)
Wong et al. (1997) <sup>15</sup>	R	ND	SBP > 220 mmHg	—	26/290 (9%)	—	11/264 (4%) <sup>g</sup>	4/26 (15%; <i>p</i> < .04) <sup>g</sup>
Scheinman et al. (1998) <sup>16</sup>	R	ND	SBP ≥ 200 mmHg	66/100 (66%)	25/100 (25%)	16/25 (64%)	0/75 (0%)	0/25 (0%)
Paciaroni et al. (1999) <sup>17</sup>	P	ND	DBP > 100 mmHg	—	20/1415 (1%)	—	0/1395 (0%)	1/20 (5%)

Note. P/R = prospective/retrospective; ND = not defined; MAP = mean arterial pressure; BP = blood pressure; SBP = systolic BP.

<sup>a</sup> Preoperative uncontrolled hypertension defined as > 170 mmHg systolic, controlled < 170 mmHg systolic but not normotensive.

<sup>b</sup> Controlled hypertension.

<sup>c</sup> Uncontrolled hypertension.

<sup>d</sup> Both patients awoke with dense hemiparesis due to intra-operative stroke rather than being complications of post-operative hypertension.

<sup>e</sup> Occurred one month after surgery.

<sup>f</sup> Awoke from surgery with neurological deficit.

<sup>g</sup> Combined stroke and death rate.

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