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Improvement in cardioplegic perfusion technique in single aortic clamping - initial results

Aperfeiçoamento em técnica de perfusão cardioplégica no pinçamento único de aorta - resultados iniciais

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Abstract

Introduction: **The most common method used for myocardial protection is administering cardioplegic solution in the coronary circulation. Nevertheless, protection may be achieved by intermittent perfusion of the coronary system with patient's own blood. The intermittent perfusion may be performed by multiple sequences of clamping and opening of the aortic clamp or due single clamping and accessory cannulation of the aortic root as in the improved technique proposed in this study, reperfusion without the need for multiple clamping of the aorta.**

Objective: **To evaluate the clinical outcome and the occurrence of neurological events in in-hospital patients submitted to myocardial revascularization surgery with the "improved technique" of intermittent perfusion of the aortic root with single clamping.**

Methods: **This is a prospective, cross-sectional, observational study that describes a myocardial management technique that consists of intermittent perfusion of the aortic root with single clamping in which 50 patients (mean age 58.5±7.19 years old) have been submitted to the myocardial revasculrization surgery under the proposed technique. Clinical and laboratory variables, pre- and post-surgery, have been assessed.**

Results: **The mean peak level of post-surgery CKMB was 51.64±27.10 U/L in the second post-surgery and of troponin I was 3.35±4.39 ng/ml in the fourth post-surgery, within normal limits. No deaths have occurred and one patient presented mild neurological disorder. Hemodynamic monitoring has not indicated any changes.**

Conclusion: **The myocardial revascularization surgery by perfusion with the improved technique with intermittent aortic root with single clamping proved to be safe, enabling satisfactory clinical results.**

Descriptors: **Anastomosis, surgical. Thoracic Surgery. Cardiopulmonary Bypass. Myocardial Reperfusion Injury.**

Resumo

Introdução: **O método mais comumente utilizado para a proteção miocárdica é o de administrar-se solução cardioplégica na circulação coronária. Entretanto, a proteção pode ser alcançada através da perfusão intermitente do sistema coronariano com sangue do próprio paciente, que é realizada por meio de múltiplas sequências de pinçamento e abertura do clamp aórtico ou por meio do pinçamento único e canulação acessória da raiz aórtica.**

Objetivo: **Avaliar o desfecho clínico e a ocorrência de eventos neurológicos no período intra-hospitalar dos pacientes submetidos à cirurgia de revascularização do miocárdio com a técnica proposta aqui neste estudo.**

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Abbreviations, acronyms & symbols	
CVA	Cerebrovascular accident
AMI	Acute Myocardial Infarction
ACE	inhibitor Angiotensin Converting Enzyme
CPB	Cardiopulmonary bypass
CABG	Coronary artery bypass grafting
COPD	Chronic Obstructive Pulmonary Disease
ICU	Intensive Care Unit
LVEF	Left ventricular ejection fraction

Métodos: **Descreve-se uma técnica de proteção miocárdica no uso do pinçamento único de aorta que consiste na canulação acessória da raiz aórtica com sistema aperfeiçoado para perfusão coronária intermitente, foi realizado estudo observacional transversal prospectivo onde foram estudados 50 pacientes (idade média 58,5±7.19 anos) submetidos à cirurgia de revascularização do miocárdio sob a técnica proposta. Foram avaliadas variáveis clínicas e laboratoriais pré e pós-operatórias.**

Resultados: **O nível médio de pico da CKMB pós-operatória foi de 51,64±27,10 U/L no segundo pós-operatório e da troponina I foi de 3,35±4,39 ng/ml no quarto pós-operatório, e estiveram dentro do limite da normalidade. Não foi observado nenhum óbito e um paciente evoluiu com alteração neurológica leve. A monitorização hemodinâmica não revelou alterações.**

Conclusão: **A cirurgia de revascularização do miocárdio com a técnica aperfeiçoada de perfusão intermitente da raiz da aorta com pinçamento único mostrou-se como método seguro, possibilitando resultados clínicos satisfatórios nos pacientes estudados.**

Descritores: **Anastomose Cirúrgica. Cirurgia Torácica. Circulação Extracorpórea. Isquemia Miocárdica.**

INTRODUCTION

Coronary artery bypass graft (CABG) is a surgical procedure well standardized in the world today, with survival rates at one year around 97%, remaining at 81% even after ten years postoperatively[1]. The development of techniques of myocardial protection during aortic clamping is largely responsible for these good results.

Myocardial protection can be achieved with the use of methods of transient ischemia, myocardial or atrial infusion of cardioplegic solution into the coronary circulation. The choice of method to be used generally depends on the behavior of the service and experience of the surgeon[2].

In an adjuvant way, a current study reports that the technique of remote ischemic preconditioning reduced the amount of release of cardiac enzymes in patients undergoing myocardial revascularization, although no difference in length of hospital stay and creatinine values were reported. This technique has its efficacy independent of myocardial protection technique[3]. Hong et al.[4] conclude that the remote ischemic preconditioning with remote ischemic postconditioning of upper limb does not improve clinical outcomes in patients undergoing cardiovascular surgery.

However, performing multiple clamping of the ascending aorta during surgery with intermittent infusion may have the unintended effect of higher incidence of neurological events due to the manipulation of atheromatous plaques in this region. A single aortic clamping should be preferred in order to reduce these events[5].

The aim of this study is to assess the clinical outcome and the occurrence of neurological events in hospital stay of patients undergoing CABG with improved technique of intermittent perfusion of the aortic root with a single clamping.

METHODS

This is a cross-sectional observational study in which 50 patients with heart failure and indication of surgery for coronary artery bypass grafting with cardiopulmonary bypass (CPB) underwent the procedure according to regular schedule and surgery by the same surgeon between August 2010 and June 2012.

Preoperative information (age, gender, diabetes mellitus II, hypertension, dyslipidemia, previous stroke, previous MI, history of smoking and alcohol consumption, COPD, CRF, ARF, LVEF and current medications) were compiled and analyzed. Intraoperative (duration of each distal anastomosis, CPB flow during each reperfusion, MAP during infusion of the aortic root, time of each reperfusion and proximal anastomosis, number of distal and proximal anastomoses, CPB and anoxia, minimum temperature during CPB, using or not of the centrifugal pump during CPB or if the CPB disconnection was in sinus rhythm or ventricular fibrillation, as well as the HR, MAP, minimum and maximum temperature, diuresis, inotropic support and IABP) and postoperative in-hospital period (neurological deficit, duration of ICU and hospital stay, and perioperative as ECG changes, urea, creatinine, creatine kinase and troponin I).

We also obtained radiographic, echocardiographic, and cardiac catheterization data. Patients were recruited only after signing Written Informed Consent (IC), in accordance with Resolution 196/96 of the National Health Council. The study was approved by the Research Ethics Committee at Real e Benemérita Associação Portuguesa Beneficência de São Paulo under the protocol number 659-10.

Inclusion criteria

The study included patients of both genders with indication for CABG surgery performed with cardiopulmonary bypass, aged up to 70 years.

Exclusion criteria

The study excluded patients who had undergone surgery without cardiopulmonary bypass with moderate or severe aortic failure on echocardiography or aortography, with clinical evidence of previous cerebrovascular disease, clinical or ultrasound evidence of carotid system disease and concomitant surgery for aortic valve failure.

Surgical strategy

The approach to the heart was median longitudinal transsternal sternotomy , inverted "T" pericardiectomy, preparation for CPB, full heparinization (3mg/kg), arterial cannulation of the ascending aorta, cavoatrial cannulation and number 14 catheter insertion in the ascending aorta for connection of airway suction and infusion, entry into cardiopulmonary perfusion (conventional membrane oxygenation), clamping of the ascending aorta, making of the distal and proximal anastomoses, in this sequence, separated by a period of reperfusion of the aortic root performed by a catheter installed in the ascending aorta, the same used for aspiration of the aorta and left cavities being connected to the output side of the aortic perfusion cannula that supplied blood to reperfusion and additional via of the same side output provided flow through the newly anastomosed graft.

When the distal anastomoses were performed, the coronary with more severe lesion or those which may revascularize greater myocardial injury territory, provided that it was not the anterior descending coronary artery so that there was risk of excessive traction of the graft of the left internal thoracic artery (in the cases of other distal anastomoses in the left coronary).

Reperfusion blood of an average of three minutes was performed after each anastomosis. This method aims to provide distal blood flow to coronary obstruction through the newly anastomosed graft using cannula connection between the aorta and the graft itself.

Using standard monitoring equipment and surgical procedure, variables were assessed during surgery such as aspect of the ascending aorta for the presence of palpable plates calcium, ischemia time during performing the distal and proximal anastomoses, mean arterial pressure of aortic root and CPB flow during periods of reperfusion of the aortic root, time of each reperfusion, CPB time, anoxia and minimum temperature reached during surgery. After the allotted time the surgery was completed as usual.

Patients were monitored until discharge as the postoperative routine laboratory tests and evolution of clinical and hemodynamic parameters.

We propose a standard two basic positions, which begin after the clamping performed once proximally to the insertion of the arterial cannula in the ascending aorta. Position 1 for perfusion and reperfusion of the aortic root (Figure 1) where there is a direct connection between the arterial cannula and the intravascular space existing between the clamped region and the aortic valve apparatus that shall be competent, otherwise there would be excessive extravasation of blood into the left ventricular cavity, reducing the inflow of blood to the coronary ostia and distending the left ventricle.

In this position 1, the connections should still be positioned so that the pressure is measured in the aortic root in order to ensure there is no method bias so that, during CPB with clamping and stopped heart, at this site there is no increase in pressure-induced vasopressors administered by an anesthesiologist or perfusionist, which could determine misinterpretations. It should also pay attention to the proper flow offered at CPB, which in this case requires no preference between roller pump or centrifugal pump.

Position 2 is the one that should be used when the time of anoxia during anastomosis, both distal and proximal, at which point "B" is closed to the side via and open to the aspirator used when necessary (Figure 2).

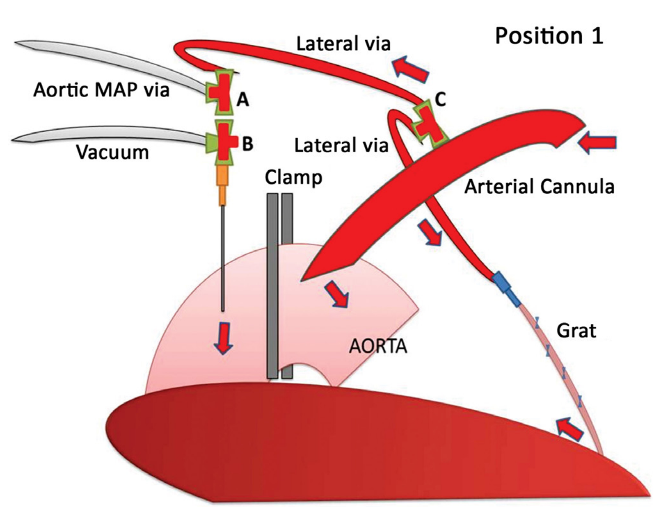

Fig. 1 - We propose a standard of two basic positions, which begin after the clamping is performed once proximally to the insertion of the arterial cannula in the ascending aorta for perfusion and reperfusion of the aortic root

A third situation is still illustrated (Figure 3), which is initially important, of a cardioplegic solution backup because if we need to use it, it is ready requiring only release the cardioplegia via and clamp and the route of the aspirator before "Y" bifurcation of the vias. In this situation the "B" point should be in the position of Figure 2.

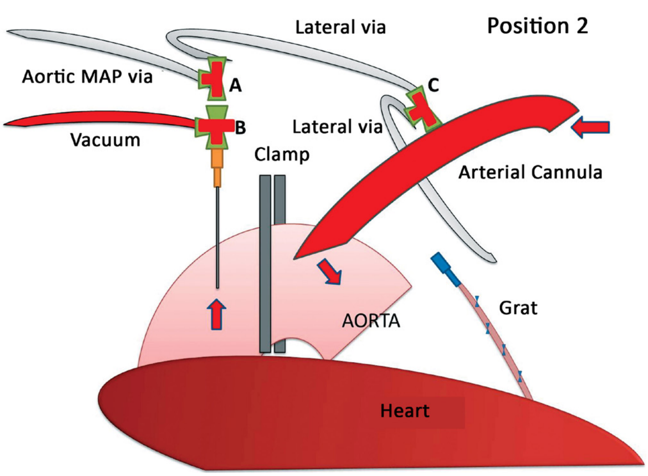

Fig. 2 - It should be used during the anoxia time during anastomosis, both distal and proximal, in which the point "B" is closed to the side via and opened to the aspirator which is used according to the need

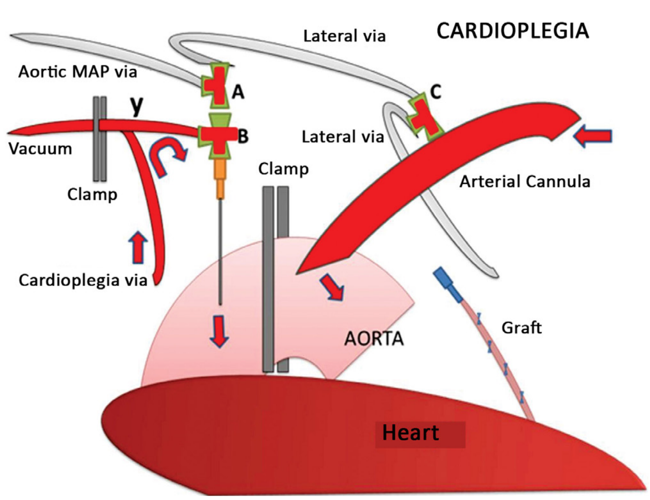

Fig. 3 - The third situation is shown, which initially is important, of back up cardioplegic solution, because if we need to use it, it is ready, requiring only releasing the cardioplegic via and clamping the aspirator via before the "Y" bifurcation of the routes. In this situation the "B" point should be in the position of Figure 2

The "C" point is fundamental to the technique because it must provide at least two routes, because during reperfusion, one or more of them should be connected to the newly anastomosed grafts, which will ensure muscle myocardial perfusion distally to the coronary lesion, since the antegrade flow by ostia may be limited by significant injuries. It is important to make sure that the "C" point is open during reperfusion.

Thus, the technique of myocardial protection is describes when using the single aortic clamping accessory which consists of cannulation of the aortic root with improved support for intermittent coronary perfusion system.

Statistical Analysis

The data of the continuous and parametric variables were expressed as mean ± standard deviation.

Patients' characteristics

Most of the patients had one or more co-morbidities such as diabetes mellitus, hypertension, dyslipidemia, smoking, COPD (Chronic Obstructive Pulmonary Disease), prior AMI (Acute Myocardial Infarction), among others (Table 1).

Table 1. Patient's characteristics.

Preoperative variables	N
Age (years)	58.5 ± 7.19
Gender (M/F)	37/13
Diabetes Mellitus II	20
Systemic Arterial Hypertension	48
Dyslipidemia	34
Previous Stroke	1
Previous AMI	27
Smoking	34
COPD	2
CRF	1
ARF	9
Alcoholism	4
Calcium in the aorta on X-ray	
Left Ventricular Ejection fraction (LVEF)	6
Good (>50%)	39
Regular (30-50%)	5
Poor (<30%)	
Drugs	35
B-blocker	
ACEI	31
Nitrate	29
AAS	36
Diuretic	11
Clexane	2
Clopidogrel	10
Insulin	2
Antiarrhythmic	1
Oral hypoglycemic	11
Statins	29
Calcium channel blockers	4

RESULTS

Of the 50 patients 37 were male and 13 were female with a mean age of 58.5 ± 19.7 years. LVEF was normal in 39 patients, good in six, and poor in five of them. Regarding the optimization of preoperative medical treatment there was great heterogeneity, where 36 patients were under use of aspirin (Salicilic Acid), 35 beta-blockers and statins 29. 31 were under use of ACE inhibitors (Inhibitor of Angiotensin Converting Enzyme) and only two were insulin dependent (Table 1).

In four patients plaques the ascending aorta were identified on palpation. All patients underwent a single aortic clamping during the entire procedure, having been required additional manipulation of the "clamp" for any reason. The average time for completion of each distal anastomosis was 9.20±1.15 minutes and during reperfusions of the aortic root the mean CPB flow was 3316.92±443.26 ml/min while the average MAP during reperfusions was 67.85±10.86 mmHg.

The time of each reperfusion averaged 3.56±0.62 minutes. To perform the proximal anastomoses were required on average 5.56±1.44 minutes. The number of distal anastomoses was on average 2.56±0.57 per patient and proximal 1.44±0.50, and the mean CPB and anoxia times of 51.66±12.21 and 31.28±8.65 minutes respectively. The minimum temperature during surgery was on average 33.90±0.65 (Table 2).

The electrocardiograms did not suffer changes different from those that may be present preoperatively and bleeding was within acceptable parameters (below 1ml/Kg/h in the early hours). There was no renal failure after CPB. The mean peak level of postoperative CK-MB was 51.64±27.10 UL in the second postoperative day and troponin I was 3.35±4.39 ng/ml on the fourth postoperative day (Table 3). Mild cognitive impairment was observed in one patient and hemodynamic monitoring revealed no changes during hospitalization, which was within the usual service standards (Table 4). No deaths were observed.

Table 2. Intraoperative variables

Intraoperative variables	
Time of each distal anastomosis (min.)	9.20 ± 1.15
CPB flow during each reperfusion (ml/min.)	3316 ± 443.26
MAP during root perfusion (mmHg)	67.85 ± 10.86
Time of each reperfusion (min.)	3.56 ± 0.62
Time of each proximal anastomosis (min.)	5.56 ± 1.44
Number of distal anastomoses	2.56 ± 0.57
Number of proximal anastomoses	1.44 ± 0.50
CPB time (min)	51.66 ± 12.21
ANOXIA time (min)	31.28 ± 8.65
Minimum temperature during CPB (°C)	33.90 ± 0.65
Use of centrifugal pump	45
Sinus CPB output	28
PV CPB output	22

Table 3. Perioperative variables

Perioperative variables	
ECG changes in the pre ► postoperative	0
Plaque of calcium in the ascending aorta	4
Surgical complications	0
Preoperative urea	37.16 ± 12.47
Postoperative urea	50.50 ± 13.80
Preoperative creatinine	1.19 ± 0.24
Postoperative creatinine	1.32 ± 0.30
Mean increase of creatinine in the pre ► postoperative	0.14 ± 0.25
Peak of postoperative CK-MB (U/L) 2º PO	51.64 ± 27.10
Peak of postoperative troponin I (ng/ml) 4º PO	3.35 ± 4.39

Table 4 - Intra- and postoperative variables

Intra- and postoperative variables	
Minimum heart rate (bpm)	72.46 ± 13.00
Maximum heart rate (bpm)	100.48 ± 15.31
Minimal MAP (mmhg)	66.84 ± 8.70
Maximum MAP (mmhg)	97.98 ± 7.36
Minimum temperature (ºC)	35.18 ± 0.55
Maximum temperature (ºC)	36.71 ± 0.44
Diuresis (ml/kg/h) in 24hs	1.32 ± 0.38
Use of tridil	43
Use of dobutamine	9
Use of IAB	0
Neurological deficit type I	1
Neurological deficit type II	0
Length of ICU (h)	56.08 ± 34.57
Length of hospital stay (days)	8.63 ± 2.74

DISCUSSION

The risk factor most important for intraoperative low cardiac output postoperatively is prolonged time of myocardial ischemia facing the effectiveness of the method used for myocardial protection[6]. Many techniques for handling myocardium during CABG are used and there is little safe evidence that a method is superior to another or that the same method is suitable in all circumstances[7].

It is known that there may be a reduction of postoperative left ventricular function even without evidence of myocardial necrosis, in the case of myocardial protection is inappropriate. Conventionally, this situation is called "myocardial stunning", or that is, a stunned myocardium[8,9].

The arguments in favor of non-cardioplegic methods include greater simplicity and, in the case of intermittent aortic cross-clamping, the proven ability of the myocardium to withstand short periods of ischemia, interspersed with periods of physiological reperfusion, without necrosis or loss of function[10,11]. In our study we found that with single clamping, with average short time of each anastomosis, either distal 9.20±1.15 minutes or proximal 5.56 ± 1.44 minutes, and always interspersed with blood reperfusion of the aorta 3.56±0.62 minutes.

It was found that brief periods of myocardial ischemia with perfusion intervals did not cause progressive depletion of high energy phosphates. This fact has a protective effect of myocardial preconditioning and proves that the injury produced by repeated clamping is not cumulative, but rather, it seems to increase myocardial tolerance to subsequent periods of ischemia[12-14]. This induction of tolerance to ischemia has been termed ischemic preconditioning (IPC)[12]. These data are confirmed in our study by myocardial markers CK-MB and troponin I within normal limits, as well as the echocardiographic control postoperatively.

The incidence of perioperative cerebrovascular accident (CVA) in the on-pump CABG ranges from 1.5% to 5.2% in prospective studies and from 0.8% to 3.2% in retrospective[3] vascular studies. The present study found only one case of mild cognitive impairment. The single most common cause of postoperative stroke is embolization of atherothrombotic debris from the aortic arch. Furthermore, only 45% of stroke after CABG are identified on the first day after surgery, while 55% of them occur after the normal recovery from anesthesia and are attributed to atrial fibrillation (AF), low cardiac output or hypercoagulable states resulting from tissue injury[15].

Risk factors for intraoperative stroke are CPB time, manipulation of the ascending aorta and arrhythmias[4]. The proposal of the authors was to present method of intermittent infusion to minimize the risk of multiple aortic clamping, as in patients with presence of atheromatous plaques in the ascending aorta may be increased incidence of strokes. In our study, we did not observe any occurrence of adverse neurological event.

The incidence of perioperative myocardial infarction in CABG ranges from 2 to 15%[16], and this variation can be explained by the absence of a gold standard test in the specific situation of infarction after coronary revascularization. In addition, electrocardiographic changes and elevation of cardiac enzymes in the postoperative period, even in patients without myocardial ischemia may occur[17,18].

International criteria for the diagnosis of MI after cardiac surgery is a new Q wave and CK-MB level > 3 times the reference value, new bundle branch block and level of CK-MB > 3 times the reference value or level of serum CK-MB > 8 times the reference value even in the absence of new Q[19] wave. Several authors have reported different cutoff points and different levels of sensitivity and specificity for troponin values as diagnostic of perioperative AMI.

Using the same enzymatic method Martinez et al.[20] found a diagnostic cutoff for troponin I in values of > 12ng/ml 10hrs after removal of the aortic clamp; Bonnefoy et al.[21] values of> 10ng/ml; Alyanakian et al.[22] values of > 15ng/mL; Gensini et al.[23] > 9.2 ng/ml after 12hrs and Sadony et al.[24] > 11.6 ng/ml after 24 hours of removal of aortic clamp. In the present investigation we found agreement with the studies described above, regarding the markers of myocardial ischemia and electrocardiographic changes.

All patients in our study underwent surgery with cardiopulmonary bypass. Various data available in the literature indicate advantage of CABG technique without cardiopulmonary bypass in selected[25] cases, however, although controversial in some points the "ROOBY" study showed no difference between the results of neuropsychological outcomes between CABG with and without CPB[26].

Intermittent perfusion of the aortic root is performed by some services as a method of myocardial protection and, although not standardized, it has been demonstrated reproducible given the simplicity of the method that requires skill and dexterity to saving time during the primary surgical time and familiarity with connections alternating aortic perfusion, the graft and simultaneous measurement of pressure in the aortic root and ascending aortic aspiration during anoxia.

The intention to provide better nutrient supply to the myocardium during intermittent infusions by this method has the benefits known and defended by adherents to the classic "intermittent aortic cross-clamping" with the additional benefit of minimal manipulation of the aorta, whereas only one clamping and unclamping of the aorta occurs, the last at the end of the proximal anastomoses.

Ko at al.[27], in 15 years of follow-up, observed that the overall mortality rate of patients undergoing CABG fell from 2.5% to 1.8%. In our study, despite the low number of patients studied, there were no deaths.

CONCLUSION

Coronary artery bypass grafting with the technique of intermittent perfusion of the aortic root with a single clamping proved to be safe, enabling satisfactory clinical and neurological outcomes in the patients studied.

Authors' roles & responsibilities

MLPS	Main Author
SFSJ	Help in bibliographical survey and review of the study
JCS	Help in tabulating the data and monitoring of patients
AST	Help in the data tabulation
DFMT	Help in the monitoring of patients in the perioperative period
TANS	Help in perioperative monitoring of patients
GGS	Article review
NAGS	Article review

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