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► To cite this version:

C. Fischer, M.P. Bonnet, A. Girault, C. Le Ray. Update: Focus in-hospital maternal cardiac arrest. Journal of Gynecology Obstetrics and Human Reproduction, 2019, 48, pp.309 - 314. <10.1016/j.jogoh.2019.02.007>. <hal-03484618>

HAL Id: hal-03484618

<https://hal.science/hal-03484618v1>

Submitted on 20 Dec 2021

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1 **Update: Focus In-hospital maternal cardiac arrest**

2

3 C Fischer¹, MP Bonnet^{1,2}, A Girault^{2,3}, C Le Ray^{2,3}

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5 1- Department of Anesthesiology and Critical Care, Hôpital Cochin, Hôpitaux Universitaire Paris
6 Centre, Assistance Publique- Hôpitaux de Paris, France

7 2- INSERM U1153, Obstetrical, perinatal and Pediatric Epidemiology Research team (EPOPé),
8 Center for Epidemiology and Statistics Sorbonne Paris Cité, DHU Risks in pregnancy, Paris
9 Descartes University, Paris France.

10 3- Port-Royal Maternity Unit, Cochin Hospital, Hôpitaux Universitaires Paris Centre, Assistance
11 Publique-Hôpitaux de Paris, DHU Risks in pregnancy, Paris Descartes University, Paris, France

12

13

14 Corresponding author:

15 Dr Catherine Fischer

16 Department of Anesthesiology and Critical Care, Hôpital Cochin

17 27, rue du Faubourg St Jacques, 75014 Paris

18 tel : 336 14 46 20 64 / 331 58 41 39 26

19 fax : 331 58 41 39 14

20 email : catherine.fischer2@aphp.fr

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24 **SUMMARY**

25 The incidence of maternal cardiac arrest ranges from 1/55,000 to 1/12,000 births. It is due
26 most frequently to cardiovascular, hemorrhagic, and anesthesia-related causes, as well as to
27 amniotic fluid embolism. The basic principles of resuscitation remain applicable in this
28 situation, but the physiological modifications of pregnancy must be taken into account, in
29 particular, the aortocaval compression syndrome. After 24 weeks of gestation, a salvage
30 cesarean delivery must be performed immediately, without transfer to the operating room, if
31 resuscitation maneuvers have failed 4 minutes after arrest, because this interval conditions
32 the mother's neurological prognosis and improves neonatal survival.

33 INTRODUCTION

34

35 The principles of modern cardiopulmonary resuscitation (CPR) of adults were introduced in
36 the 1960s, but their application to pregnant women appeared only 30 years later and
37 occupied only a few lines in the text of clinical practice guidelines. The particularities of
38 maternal CPR are better known today and are covered in specific guideline sections (1,2).
39 Consideration of the physiological modifications of the cardiopulmonary system associated
40 with pregnancy is essential for effective CPR of pregnant women. These changes involve
41 cardiac output, blood volume, ventilation, and oxygen consumption, all of which increase
42 during pregnancy. Moreover, the gravid uterus causes compression of the abdominal and
43 iliac vessels, especially in the dorsal decubitus position, where this results in decreased
44 cardiac output and blood pressure. The standard initial management of cardiorespiratory
45 arrest must therefore be adapted to these physiological modifications. Nonetheless, if
46 cardiac activity does not resume within 4 minutes after maternal cardiac arrest (MCA), even
47 after appropriate basic or advanced cardiac life support (BLS and ACLS), a perimortem
48 cesarean delivery (PMCD) is an essential part of fetal but especially maternal salvage.

49 Cardiac arrest during pregnancy is extremely rare but maternal and fetal outcome depend
50 on the speed and effectiveness of the resuscitation procedures. This extraordinary situation
51 requires coordinated intervention by obstetrics, anesthesiology, and neonatology teams,
52 which must share the same management objectives. These objectives and the algorithm for
53 maternal resuscitation must be known beforehand by all participants to implement optimal
54 management.

55

56

EPIDEMIOLOGY

57

58

59 - Incidence of maternal cardiac arrest

60 Because of the rarity of this event, the incidence of MCA is difficult to calculate. Several
61 recent population-based studies in Canada and the United States (US) have assessed the
62 incidence of MCA at around 1/12,000 hospitalizations for delivery (3,4). A retrospective
63 nationwide study in Canada identified 286 cases of MCA between 2002 and 2015 among
64 3,568,597 admissions, for an incidence of 8/10,000 hospitalizations and a maternal survival
65 rate of 71% (3). In a US study, Mhyre et al. found a similar incidence, with 4843 cases of MCA
66 between 1998 and 2011 among 56,900,512 hospitalizations and a 59% maternal survival
67 rate (4).

68 Moreover, enquiries that monitor and analyze maternal deaths have shown a significant
69 increase in the number of PMCDs during this century: 52 cases were reported in the United
70 Kingdom (UK) in 2003-2005, double the number reported during the preceding three-year
71 period (5). Similarly, a retrospective study in the Netherlands showed that this procedure
72 increased over a 15-year period (6).

73

74 - Risk factors

75 Although maternal mortality has remained stable in most countries that have been analyzing
76 these data for several decades by appropriate methods, severe maternal morbidity is rising.
77 A higher incidence of cardiovascular comorbidity in pregnant women, associated in part
78 with the increase in maternal age, explains this phenomenon in part. African ancestry and
79 social and economic vulnerability are other risk factors of maternal cardiovascular
80 morbidity described in the US (7).

81 Among the 4843 cases of in-hospital MCA reported by Mhyre et al., the most frequently
82 associated comorbidities were pulmonary arterial hypertension, cancer, cardiovascular and
83 liver disease, and systemic lupus erythematosus (4). The obstetric risk factors included fetal
84 death, cesarean delivery, severe preeclampsia, and placenta previa.

85 In the Canadian study, Balki et al. reported the following risk factors for MCA: maternal age
86 (with an OR of 1.8 for women aged 35-39 years and 3.1 for those 40 years or older), grand
87 multiparity (> 4, OR 2.08), as well as gestational age younger than 32 weeks (OR between 14
88 and 16) (2). The obstetric risk factors were abnormal placental insertion and
89 polyhydramnios. Associated maternal comorbidities were cancer (OR 8.4), neurological and
90 respiratory diseases, hypertensive disorders of pregnancy, and gestational diabetes.

91 Contrary to the study by Mhyre et al., cardiovascular diseases did not appear to be risk
92 factors in the Canadian study, but we must note that it included substantially fewer cases of
93 MCA than the US study: 286 vs 4843 (4).

94

95 **Maternal Cardiac Arrest: CAUSES and PROGNOSSES**

96

97 - **Causes and maternal prognosis**

98 Among the causes of MCA, hemorrhage — antepartum or postpartum — remains the most
99 frequent. Nonetheless the incidence of MCA in women with a hemorrhage is below 1/1000.
100 Amniotic fluid embolism is the disorder most frequently often complicated by MCA, followed
101 by myocardial infarction and thromboses. Table 1 reports the frequencies of the causes of
102 MCA reported by these two studies and survival rates by cause (3,4).

103 Between 2011 and 2014, a prospective study in the UK identified 66 MCAs among 2,347,670
104 pregnancies, for an incidence of 2.8/100,000 pregnancies and a maternal survival rate of
105 58% (8). In this study, the leading cause of MCA was anesthesia-related (17 of 59 cases),

106 with a survival rate of 100%, followed in order of decreasing frequency by hypovolemia (13
107 cases, survival 38%), amniotic fluid embolism (8 cases, survival 62%), venous thrombosis (8
108 cases, survival 12%), cardiac causes (6 cases, survival 83%), cerebral hemorrhage (3 cases,
109 survival 0%), aortic dissection (2 cases, survival 0%), cardiac tamponade, asthma, and
110 pulmonary artery rupture (1 case each). Besides the anesthesia-related causes, which had an
111 unexpectedly high incidence in this study, the other causes of MCA were essentially those
112 found in surveys of maternal mortality (5): 38 women (58%) survived after their initial
113 cardiac arrest. Among the complications, 6 were neurological, 5 hemorrhages, 2
114 coagulopathies, 2 renal, and 1 cardiac. Details of intermediate- to long-term maternal
115 outcomes were not provided.

116 The specific place that MCA occurs and the speed of its management are crucial prognostic
117 factors. In the study by Beckett et al., the group of women who died was characterized by its
118 higher proportions of MCA at home and of women who were moved for a cesarean delivery,
119 as well as by a longer delay between MCA and the start of resuscitation. MCA from
120 anesthesia-related causes, corresponding to cardiovascular complications of regional
121 anesthesia, was associated with excellent maternal survival, explained in large part by their
122 occurrence in a place where rapid management, especially surgery, was possible, due to the
123 nearly immediate presence of anesthetists and obstetricians (operating suite, delivery room)
124 (8).

125 Globally, the survival rates for MCAs reported in the literature are lower than those for
126 cardiac arrest in the general population of adults (9,6).

127

128 - **Fetal prognosis**

129 Fetal prognosis is closely linked to that of the mother and thus to the speed of resuscitation.

130 In the UK prospective study with 66 cases of MCA, 46 fetuses were liveborn (32 to mothers
131 who survived and 14 to mothers who died). When cesareans were performed within 5

132 minutes of MCA, neonatal survival was 96%, compared with 70% for delays exceeding 5
133 minutes. The other factors associated with better neonatal survival were maternal survival,
134 birth weight, and gestational age, as well as reassuring neonatal markers (Apgar score and
135 pH). The rates of complications and sequelae among the surviving "newly borns" were
136 similar among those whose mothers did and did not survive (8). These data confirm that
137 maternal resuscitation is the most important element of fetal salvage.

138 In another series of 94 cases of MCA published in 2012, the neonatal survival rate among the
139 66 viable fetuses delivered by PMCD was 64% (10). The time between MCA and PMCD —
140 14+/-11 minutes among the survivors and 22+/-13 minutes for the nonsurvivors —
141 underlines the importance of the speed of the cesarean delivery in this context.

142

143

MEDICAL MANAGEMENT

144 Cardiac arrest is defined as the cessation of cardiac activity. Nonetheless verifying the
145 absence of a palpable pulse is not essential for this diagnosis. All the guidelines stipulate that
146 a patient who does not respond and is not breathing or is breathing abnormally requires
147 immediate resuscitation, that is, chest compression and, if possible, ventilation.

148

- BASIC LIFE SUPPORT

150

151 Initial management is based on the principles of basic CPR or life support (BLS), known to
152 all. All major steps of BLS are reported in table 2.

153 The objective of chest compression is to press the chest down hard to a depth of 5 to 6 cm (2
154 to 2.4 inches) at a frequency of 100/min and a 1/1 relaxation/compression ratio. Any
155 interruption of ECM compromises coronary vascularization and reduces the chances of
156 survival. If ventilation can be provided (with an external mask), the ratio of chest

157 compressions to insufflations must be 30/2, without any interruption of ECM. This should
158 enable, at best, the return of spontaneous circulation (ROSC) at 20% of the normal level.
159 Coronary perfusion is not assured because diastolic pressure cannot be restored by ECM
160 alone, and cerebral perfusion remains mediocre, < 20% of normal. These initial procedures
161 should be done until advanced cardiac life support (ACLS) is delivered. Particular attention
162 must be paid to the time, which must be noted very precisely: time of MCA occurrence and of
163 the start and duration of ECM.

164 Table 2 shows these modified principles, applicable to pregnant woman:

- 165 - first, the call for help must include a call for an obstetrician and a pediatrician, ideally a
166 neonatologist
- 167 - the operator's hand position for ECM must be mediosternal (a little higher) because of
168 the ascension of the diaphragm
- 169 - as soon as the uterus size is above the umbilic, manual displacement of the uterus to the
170 left must begin immediately, as well as preparation for a cesarean, in case resuscitation
171 does not succeed rapidly (1).

172

173 **- ADVANCED CARDIAC LIFE SUPPORT**

174 This stage of MCA management must also be adapted to the physiological modifications of
175 pregnancy.

- 176 - The pregnant uterus, responsible for aortocaval compression syndrome, severely
177 compromises the efficacy of ECM. One member of the team must be assigned to continuously
178 displace the uterus laterally leftward. The procedure consists in cupping the uterine fundus
179 with both palms and pushing to the left while lifting it as much as possible to free the vena
180 cava and the aorta. It was initially recommended that ECM be performed with the woman in
181 left lateral decubitus, by using various types of objects to keep her on her side (inclined

182 plane, a side block, a chair, etc.). But simulation tools have shown that ECM in a lateral
183 decubitus position is much less effective than in dorsal decubitus. The force developed by
184 the operator is stronger when he or she is vertically above the chest (67% of body weight)
185 and diminishes with the slope of the surface (36% at 90°) (11). Manual lateral displacement
186 is more effective than a 12° slant for maternal hemodynamics during cesarean delivery (12).
187 - The position of the hands during ECM must be more or less mediosternal because of the
188 pregnancy-related elevation of the diaphragm.

189 - Although procedures for maternal BLS and ACLS follow the standard guidelines for adults,
190 steps to restore ventilation must be started earlier for MCA. Intubation by an expert (senior
191 anesthesiologist) is recommended when possible, as well as the use of a small-diameter
192 tube. End tidal CO₂ should be continuously monitored as soon as possible in order to assess
193 the efficacy of chest compressions and to confirm correct endotracheal tube placement.
194 Indeed, end tidal CO₂ above 10 mmHg or rising during resuscitation may correlate with the
195 return to spontaneous circulation (2).- Early intravenous or intraosseous vascular access
196 must be rapidly established; it must be supradiaphragmatic, to reduce delay in the time for
197 drugs to reach the heart in case of caval compression.

198
199 The medical principles of ACLS for adults apply without modification for pregnant women
200 concerning:

201 - Use of epinephrine: 1-mg bolus every 3-5 minutes
202 - Direct current cardioversion (DCC) (for shockable rhythm), at the same frequency and
203 intensity as usual. A study showing that pregnancy does not modify thoracic impedance
204 suggests that the same intensity of DCC should be used for pregnant women (13). The only
205 precaution is that the electrodes should be placed such that the current does not pass by the
206 uterine cavity, that is, one anterior chest electrode and one left posterolateral, placed
207 adequately high. A case report reviewing the literature counted 40 women treated by DCC

208 for severe arrhythmias during pregnancy and reported in nearly all the cases (38/40) that
209 the fetus was not harmed by this treatment. On the contrary, maternal ROSC was
210 accompanied by improvement in fetal condition. On the other hand, DCC directed at the fetus
211 is associated with neonatal mortality of 75% (14).

212 Fetus condition should not be considered at this stage, except for assessing gestational age
213 (before or after 24 weeks). No monitoring (ultrasound or FHR/CTG) should be established;
214 indeed it should be removed or disconnected after MCA. First, the metal sensor can be
215 dangerous during cardioversion shocks. Second, assessment of fetal condition must not
216 modify or delay execution of the algorithm for maternal resuscitation.

217 In the specific case of MCA due to excess magnesium sulfate for the treatment of severe
218 preeclampsia, the magnesium sulfate infusion should be stopped and its antidote, calcium (1
219 g), injected.

220

221

222 **PERIMORTEM CESAREAN AT 4 MINUTES AFTER MCA**

223

224 As mentioned above, maternal and neonatal survival both depend closely on the speed of
225 maternal management and the performance of a so-called perimortem cesarean delivery
226 (PMCD), ideally 4 minutes at most after the MCA.

227

228 **- Rationale**

229 In the 1980s, despite modernization of the principles of CPR, cases of unexpected failure of
230 resuscitation after MCA during pregnancy were reported (15). During that decade, several
231 authors also reported ROSC after cesarean deliveries performed after maternal resuscitation
232 had apparently failed (16). A review of the literature published in 2005 identified 38 cases of

233 PMCDs published between 1985 and 2004. In more than half of the cases documenting
234 subsequent maternal condition (12/22), authors reported spectacular and immediate
235 improvement in maternal hemodynamics after the PMCD. Cesarean delivery was performed
236 within 4-5 minutes in only 8 of the 38 cases in this series (17).

237 A retrospective Dutch study analyzed 55 MCAs in the 1993-2008 period; PMCD was
238 performed in only 12 of them, but the authors noted that this rate increased substantially
239 after the initiation of the MOET (Managing Obstetric Emergencies and Trauma) program,
240 which recommended the performance of PMCD (the PMCD rate rose from 0.36/year to
241 1.6/year). In those 12 cesareans, 67% (n=8) of the women had recovered spontaneous
242 cardiac output at the end of the delivery, but maternal mortality remained very high (83%)
243 and the only two survivors had severe neurological sequelae. No PMCD was performed
244 within 5 minutes of MCA; delays were attributed to the transfer of women to the operating
245 room and/or assessment of fetal condition (6).

246 The principal benefit expected from operative fetal intervention when maternal
247 resuscitation fails is improvement of the effectiveness of ECM; potential fetal salvage is only
248 a secondary aim. This decision is, nonetheless, justified only after 22-24 weeks, or when the
249 gravid uterus extends beyond the umbilicus. That is, effective ECM that follows standard
250 guidelines does not enable the restoration of the cardiac output to more than 15-30% of
251 normal. Moreover, caval compression by the gravid uterus reduces the filling volume of the
252 right heart and the global flow proportionally to the uterine volume; this compression is
253 maximum in the dorsal decubitus position and can result in complete occlusion of the
254 inferior vena cava (which accounts for two thirds of total venous return). In the mid-third
255 trimester, in dorsal decubitus position, cardiac output is thus reduced by 30 to 40%. The
256 combination of these two factors (low restoration by ECM and aortocaval compression
257 syndrome) severely impairs the performance of maternal resuscitation. Overall, only 10-
258 15% of cardiac output can be obtained in these conditions. This very low blood flow is

259 expressed by low maternal cerebral blood flow that, when maintained for more than 4 to 6
260 minutes can lead to irreversible anoxic neurological sequelae. For the same reasons,
261 neonatal survival also depends on the duration of this low flow.

262 Manual lateral uterine displacement can certainly improve this result. Nonetheless if initial
263 maneuvers fail past this 4-minute deadline on which maternal neurological prognosis
264 depends, the uterus must be emptied to relieve this compression and enable ECM to
265 continue in the best conditions.

266 Other potential benefits accompany the PMCD: improvement of lung compliance by reducing
267 intra-abdominal pressure and fetal oxygen needs, restitution of the uterine portion of the
268 total blood flow (10-20%) and, later, the mechanism of vascular flow associated with uterine
269 contractions.

270 On the other hand, ECM must not in any case be interrupted, because that will worsen the
271 mother's survival and functional prognosis. Moving her (by stretcher, elevator, etc.) for a
272 cesarean delivery in the operation room impairs the effectiveness of ECM and of DCC. It is
273 therefore recommended that the cesarean be performed, like the resuscitation, where the
274 MCA occurred, even in the absence of aseptic conditions. In the CAPS prospective study in
275 the United Kingdom, 41 PMCDs were performed among the 66 antepartum MCAs, including
276 11 cesareans in the ER, not in the OR. In the survivors' group (38 women), the delay between
277 MCA and PMCD was significantly shorter (7 min (2.5-17.5)) than in the group of women who
278 died (16 min (6.5-43.5)). For women who had a cesarean without being moved (n=25),
279 survival was 72%, compared with 36% for the women who were transferred. PMCD was not
280 performed at all for the other 17 women, because cardiac output was restored (n=6), or
281 gestational age was < 20 weeks (n=6), or for another reason (n=5) (8).

282

283 - **In practice**

284 The recent international guidelines unanimously recommend a rapid cesarean: once the
285 uterine volume reaches or extends past the umbilicus (20-24 weeks), a cesarean is indicated
286 to save the mother's life between 20 and 24 weeks and for both the mother and fetus at and
287 after 24 weeks (1). Nonetheless, although PMCD is recognized as a key intervention on
288 which maternal and fetal survival depend, many providers do not appear to know this, given
289 that it is actually performed in only around one third of the maternal deaths after 24 weeks
290 (18).

291 The 4-minute rule is an objective to strive for; it requires that the obstetric team be ready to
292 perform a cesarean delivery once the MCA is observed and to perform a hysterotomy > 4
293 minutes later, in the absence of return to spontaneous circulation. Nonetheless, even after
294 this delay, the cesarean delivery must be performed: on the one hand, a live newly born baby
295 can be delivered even after 30 minutes of maternal resuscitation; on the other hand, even
296 though the maternal neurological prognosis is associated with the duration of cerebral
297 anoxia, this duration can only be assessed retrospectively.

298 Hesitancy and its many reasons are nonetheless obstacles to the performance of an
299 immediate onsite cesarean in this context: nonsterile environment, minimal equipment, fear
300 of a hemorrhage or legal consequences, and an erroneous belief that the cesarean is
301 performed exclusively for the fetus's benefit. But these considerations may be offset by the
302 failure of resuscitation past the time when maternal neurological prognosis and fetal
303 survival seem unlikely.

304 The decision to perform a cesarean must not interrupt the resuscitation procedure, ECM in
305 particular. No fetal assessment (ultrasound or monitoring) should be performed at this
306 stage; the PMCD decision depends only on the failure of resuscitation. Any supplementary
307 examination necessarily delays management and/or interrupts ECM, even if only for several
308 seconds. Rapid and shared decision-making is facilitated if the scenario has been envisioned
309 in advance, by simulation for example. The use of checklists or cognitive aids (posters, cards)

310 read by one of the participants (who also announces the timing) is also useful in this context
311 (19).

312 The cesarean must be performed in the same place as the MCA and CPR insofar as possible,
313 generally by a midline laparotomy, while continuing ECM, epinephrine injections, and DCC if
314 indicated. The placenta must be removed immediately after the fetus; nonetheless the risk of
315 hemorrhage is not at the forefront since by definition there is no spontaneous cardiac
316 output. If ROSC occurs, physicians should be aware of the risk of major bleeding. Thus, the
317 woman should then be transferred to the operating room, especially for hemostatic
318 procedures

319 In practice, the only essential equipment is a scalpel, but some authors recommend
320 equipping emergency carts in obstetric departments with a minimum set of surgical
321 equipment, in particular, cord clamps, retractors, and sutures (19, 20).

322 In the prospective CAPS study, 12 PMCDs were performed with no aseptic measures (no
323 gloves, no skin preparation, no fields...). A scalpel was available in the resuscitation cart in
324 55% of cases (8).

325 Table 2 summarizes the principles of management for MCA: *basic life support, advanced*
326 *cardiac life support*, and a cesarean at 4 minutes.

327

328 **EXTRACORPOREAL LIFE SUPPORT**

329 Following delivery, if return to spontaneous circulation has not been achieved,
330 cardiopulmonary bypass or extracorporeal membrane oxygenation (ECMO) should be
331 systematically considered (22). A call number for ECMO referral center should be identified
332 and mentioned in a check list (Figure 1).

333

334 **UTILITY OF SIMULATION**

335 Numerous studies have shown that simulation programs are excellent educational tools for
336 interns and residents, but also important as techniques to improve the skills of more
337 experienced providers for rare and serious situations (21, 24). Emergency decision-making,
338 team leadership, organization, and communication, the use of checklists, cognitive aids and
339 protocols, identification of errors, assessment of individual and group performance — all of
340 these are aspects that can be enhanced by simulation exercises, especially as a team. While
341 individual continuing education about MCA resuscitation is generally provided regularly
342 within hospitals, the specificities of the management of pregnant women and the aspects of
343 multidisciplinary coordination within a team are covered only rarely.

344 Assessments of knowledge and performance most often show the inadequacy of the
345 preparation of obstetric and neonatal teams to manage maternal MCA (10, 23). The
346 comparative before-and-after evaluation of a group simulation exercise showed significant
347 improvement of all performance indicators, especially for PMCD decision-making (21).
348 Analysis of the videotape of an MCA simulation exercise makes it possible to document the
349 points requiring improvement. In one study of this type conducted in an unprepared
350 obstetric team (nurses, obstetricians, and anesthesiologists), the authors found that ECM was
351 performed correctly in only 56% of cases, ventilation in 50%, and lateral uterine
352 displacement was performed in only 56% of cases (24). Delays in management are
353 shortened, especially ECM initiation and PMCD decision-making, after a team simulation
354 program (25). Establishing immersion training and simulation program within
355 multidisciplinary teams that may face this type of crisis situation makes it possible to
356 improve the recognition of signs of life-threatening maternal distress, the practice of
357 survival procedures (ECM, defibrillation, ventilation, lateral uterine displacement), the
358 reflexes and organization of PMCD in 4 to 5 minutes, the coordination and implementation of
359 multidisciplinary codes and procedures (24). All members of obstetrical and
360 anesthesiologist teams should have an easy access to cognitive aids and check lists for MCA

361 management and be regularly trained through simulation sessions (Figure 1). The
362 establishment of this type of program is recommended by international guidelines on this
363 topic (1, 2).

364

365 **CONCLUSION**

366 In-hospital MCA is a rare and serious event that healthcare providers in obstetrics must
367 prepare themselves to face. The maintenance of skills as part of a training and simulation
368 program must be organized regularly. The specific maneuvers of resuscitation must be
369 coordinated and implemented in a multidisciplinary manner: the particularities of
370 management associated with aortocaval compression by the gravid uterus, which requires
371 manual lateral uterine displacement during ECM, and the risk of early hypoxia, which must
372 lead to rapid oxygenation. For the first minutes, and regardless of gestational age, the
373 objectives of management aim solely for maternal ROSC and follow the algorithms for adult
374 BLS and ACLS. If the initial attempt at resuscitation fails and after 20 weeks of gestation,
375 cesarean delivery performed at the MCA site, without interrupting the cardiac massage, can
376 improve maternal prognosis by releasing the aortocaval compression. After 24 weeks, it may
377 allow enable fetal salvage. The 4-minute rule conditions the maternal neurological
378 prognosis.

379

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438 Table 1. Causes of maternal cardiac arrest and survival rates according to cause
 439 (nonexclusive categories)

<i>Causes of MCA</i>	Canada 2002-2015 N=286		USA 1998-2011 N=4843	
	MCA	Survival	MCA	Survival
Postpartum hemorrhage	39%	70%	28%	55%
Antepartum hemorrhage	20%	65%	17%	53%
Heart failure	31%	70%	28%	55%
Anesthesia	13%	100%	8%	82%
Amniotic fluid embolism	13%	67%	13%	52%
Trauma	12%	56%	3%	23%
Sepsis	9%	60%	11%	47%
Eclampsia	7%	85%	6%	76%
Pulmonary embolism	6%	53%	7%	41%
Stroke	5%	46%	4%	40%
Acute pulmonary edema	5%	77%	2%	71%
Myocardial infarction	1%	33%	3%	56%
Aortic dissection	1%	25%	0.3%	0

440

441 Table 2. Principles of MCA management

<u>MATERNAL CARDIAC ARREST</u>		
BLS <i>(4 staff members)</i>	<ul style="list-style-type: none"> ▪ Call for help ▪ Note the timing ▪ Start ECM at 100/min on a firm surface ▪ Manual lateral uterine displacement ▪ Free the upper airways 	Anesthetist Obstetrician Neonatologist
Prepare simultaneously for an onsite cesarean		
ACLS <i>(Specific team)</i>	<ul style="list-style-type: none"> ▪ Ventilation FiO2 100% ▪ Orotracheal intubation ▪ Supradiaphragmatic venous access ▪ Epinephrine IVD 1 mg/3-5 min ▪ DCC (except for asystole) 	<i>No fetal sensors</i> <i>Stop MgSO4</i>
<p><i>If failure and term > 20 weeks</i></p> <p style="text-align: center;">↓</p> <p>Cesarean without transfer at 4 minutes</p>		

442 BLS: basic life support, ACLS: advanced cardiac life support

443 IVD: intravenous direct, DCC: Direct current cardioversion

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447 Figure1. Check list for the management of the first minutes of maternal cardiac arrest

