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CASE REPORT

Compressive blunt trauma of the abdomen and pelvis associated with abdominal aortic rupture

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Blunt trauma to the abdominal aorta is an uncommon but life-threatening injury. Its incidence and mortality are related to road traffic accidents and have increased during the last years mainly because of the compulsory use of seat belts. A high level of suspicion and medical knowledge is necessary for its diagnosis and appropriate management. We present a rare case of abdominal compression leading to pelvic fracture and disruption of the aortic wall with a fatal result. With this case study and a literature review, we would like to stress the importance of recognition, management and follow-up of the blunt abdominal injuries associated with pelvic trauma in order to improve the outcome.

Keywords : abdominal trauma ; aortic rupture.

INTRODUCTION

Blunt abdominal trauma with any type of insult to the abdominal aorta is a rare and life-threatening injury ; it is especially rare in children (*19*). Blunt injuries to the thoracic aorta are more frequent, compared to the blunt injuries of the abdominal aorta (*3, 5, 21, 22, 26*). The abdominal aorta, situated in the retroperitoneum, is relatively well protected by the spine, the rib cage and the abdominal viscera. The abdominal aortic lesions can occur from transmission of direct or indirect mechanical forces during high- or low-speed impacts. Delayed diagnosis of this type of injury is not infrequent, especially when other injuries are associated, and a high level of suspicion and medical knowledge is needed for their diagnosis and appropriate management.

The authors present a rare case of blunt abdominal aortic rupture with associated pelvic fracture and hip dislocation, secondary to abdominal-pelvic compression. A review of the literature is also presented in order to stress the importance of early recognition and management of these life-threatening injuries.

CASE REPORT

A 41-year-old man was seen in another hospital with abdominal and pelvic injury after being caught in a pressure machine for 3 minutes. He

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Fig. 1. — Antero-posterior radiograph of the pelvis : left and right sacroiliac joint disruption and posterior dislocation of the left hip.

complained of lower abdominal pain with guarding. He was hypotensive (systolic blood pressure : 88 mm Hg) and tachycardic (100/min), but his oxygen saturation and respiratory rate were normal. He also complained of pain over the left sacroiliac joint, and over the left anterior thigh, which was kept in flexion and internal rotation. Neurological compromise of the left lower leg was apparent : active dorsiflexion of the left ankle was impossible and there was hypaesthesia in the left L4-L5-S1 dermatomes. The palpation per anum was painless and the prostate was at the normal level. There was absence of blood on the meatus urinarius, and the urethrogram was normal. The radiographs revealed an "open book" type of pelvic fracture with left and right sacroiliac joint disruption, and a posterior dislocation of the left hip (fig 1). An ultrasonogram of the abdomen revealed free fluid. Initial resuscitation efforts failed to provide haemodynamic stability and the patient was taken promptly to theatre for application of an external fixator, urgent laparotomy and reduction of the dislocated hip. After application of the external fixator, a midline laparotomy was performed. The liver and spleen were found intact. A serosal tear of the sigmoid colon was sutured. No active bleeding was seen, but there was a large retroperitoneal haematoma (fig 2), extending to both flanks ; it was left undisturbed, because it was seen as a consequence of the pelvic fracture. The abdominal wall was closed. Attempted closed reduction of the left hip dislocation was unsuccessful and the patient was kept in skeletal traction. The vascularity of the lower limbs was found normal and symmetrical by a vascular surgeon. Four hours later, and having achieved haemodynamic stability with 17 units of blood, 2 units of fresh frozen plasma (FFP) and 4 litres of crystalloids, a CT-scan of the spine and pelvis was performed. Apart from the above-mentioned injuries, fractures of the transverse processes L4 and L5 were noted.

The next day open reduction of the left hip was performed via a Kocher-Langenbeck approach (in the lateral position due to the presence of the external fixator). The femoral head was found to have buttonholed through the gemelli muscles and the internal obturator muscle. The pelvic ring was bilaterally stabilised with sacroiliac screws, and the external fixator was adjusted accordingly (fig 3a, 3b). After the second operation, 8 more units of blood, 5 units of platelets and 4 units of FFP (in addition to the crystalloid and colloid solutions) were administered. The purpose of the crystalloids was to provoke alkaline diuresis and to prevent myoglobin-induced renal failure secondary to the crush injury.

Following extubation, 48 hours after the second operation, the patient was alert and orientated ; his Glasgow Coma Scale was 15/15. The patient remained haemodynamically stable throughout the subsequent days without any signs of acidosis, hypoxia or hypotension. Unfortunately, he suddenly collapsed on the 8th postoperative day, sitting in a chair. Despite vigorous resuscitation efforts for over 20 minutes he was eventually pronounced death.

His haematological picture the morning prior to his death was quite satisfactory : Hb 11 g/dl ; platelet count 230,000/mm^3. The initial clinical diagnosis for the cause of his death was a massive pulmonary embolism. However, the post-mortem examination revealed a small disruption of the aortic wall just below the level of insertion of the renal arteries. The coroner diagnosed death from sudden exsanguination secondary to this abdominal aortic lesion.

Fig. 2. — CT- view of the retroperitoneal haematoma (arrows)

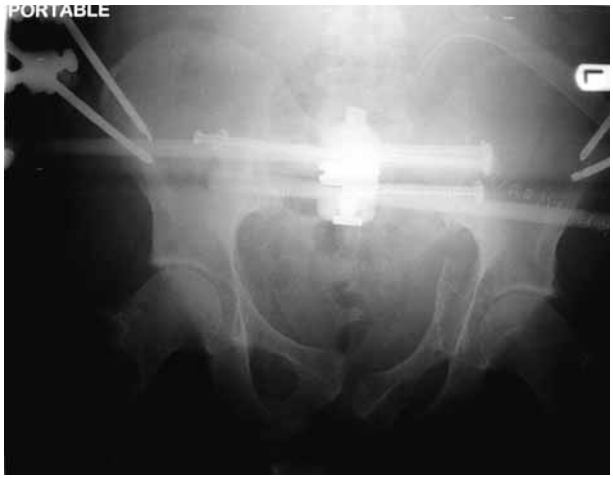

Fig. 3a. — Antero-posterior radiograph of the pelvis after external fixation and percutaneous insertion of cannulated screws in the sacroilioac joints.

Fig. 3b. — Inlet view of the pelvis after external fixation and percutaneous insertion of cannulated screws in the sacroiliac joints.

DISCUSSION

Incidence

Blunt injury to the abdominal aorta is uncommon, as the aorta and iliac arteries are relatively well protected in the retroperitoneum. Abdominal aortic rupture is more commonly seen in cases of penetrating abdominal trauma, whereas the thoracic aorta is usually ruptured after blunt trauma. Blunt injuries of the thoracic aorta are well known and account for about 95% of all injuries involving the aorta (*3, 5, 21, 22, 26*). In a review of 870 patients who underwent laparotomy for blunt abdominal trauma, only one (0.11%) had an aortic injury (*3*). Studies in the late 1930s and early 1940s reported an incidence of thoracic and abdominal *aortic* blunt trauma of less than 1% of all fatal blunt abdominal trauma, but more recent studies reported an incidence of 10% - 15% (*5*). This increase is associated with the use of seat-belts (especially lap-type seat-belts), with the impact from steering wheels and most probably with the higher speed of the motor vehicles (69% of abdominal aortic injuries are vehicle-related) (*19*). It is noteworthy that only 8 paediatric cases of operated abdominal aortic ruptures have been described in the literature until now (*6, 9, 11, 12, 19, 26, 30, 34*). Reported cases of both adult and paediatric abdominal aortic ruptures are shown in tables I and II.

Table I. — Published adult cases of blunt aortic disruption

Author / Study	**Age**	**Mechanism of injury**	**Level / Type of aortic injury**	**Associated injuries**	**Early assessment of aorta**	**Late / Secondary assessment of aorta**	**Treatment of aortic lesion**	**Outcome**
Sinclair & Stephenson 1972 *(28)*	31	Thrown out of vehicle during a car crash	Tear at **aortic bifurcation** **(Delayed rupture)**	Facial fractures Small chip fracture of the body of L5		**D+1** : hypotension + cardiac arrest → **DPL** : positive → **Laparotomy** : Retroperit. haematoma + tear aortic bifurcation	Surgical repair (running suture)	Uneventful
Lupetin *et al* 1990 *(15)*	29	20ft fall	Linear transmural tear post. wall of **infrarenal aorta** (50% circumference) + tense pseudoaneurysm		**Abdo-CT** : aortic rupture + pseudo-aneurysm + bilateral retroperitoneal haematoma		Surgical repair	Uneventful
Reisman *et al* 1990 *(24)*	55	Pinned between automobile and tool chest	Complete transection of calcified aorta **below the renal arteries +** large **intimal tear** extending into r. iliac artery + thrombosis	Ruptured left hemi-diaphragm, stomach perforation, multiple serosal tears of small bowel, multiple orthopaedic injuries	**Urgent laparotomy**		Gore-Tex bifurcation graft	Deceased by multiple organ failure, 2 months later
Brathwaite & Rodriguez 1992 *(2)*	29	30ft fall	Complete transection **just beneath renal arteries**	Cardiac arrest at scene and after DPL → thoracotomy for aortic cross-clamping and open heart massage inferior caval tear	**Laparotomy** (no peritoneal blood but large retroperitoneal haematoma)		End-to-end repair	Cardiac arrest ; patient did not tolerate aortic unclamping
Brathwaite & Rodriguez 1992 *(2)*	19	Thrown from motorcycle	Small **tear just caudal to the inferior mesenteric artery**	l. pneumothorax + pulm. contusion, r. 1st rib fracture, jejunal + transv. colon serosal tears	**DPL** : positive **Laparotomy** : bowel serosal tears + aortic tear caudal to the IMA		Surgical repair (mattress surgical technique)	Uneventful
Lyons 1992 *(16)*	19	Violent contact with a football goalkeeper's flexed knee	Small posterolateral transmural rupture of the **infrarenal aorta** **Torn lumbar artery** and vein	Small bowel serosal contusion	**DPL** (**30-60 min after admission**) : positive **laparotomy** : retroperit. haematoma, small posterolat. transmural rupture of infrarenal aorta, Torn lumbar artery + vein		Surgical repair (interrupted sutures)	Uneventful

DPL = Diagnostic Peritoneal Lavage ; IMA = Inferior Mesenteric Artery.

Michaels *et al* 1996 (*18*)	23	Entrapped in a rollover motor vehicle crash	Complete disruption of aorta at the **bifurcation**	Serosal injury to transverse colon	**Abdo-CT** : retroperitoneal extravasation at level of aortic bifurcation.		Aorto-iliac graft	Uneventful
Naude *et al* 1997 (*20*)	71	Lap-belt restrained passenger	Post-mortem exam : Complete circumferential disruption of the calcific intima and media **just above the bifurcation**. Adventitia, keeping 2 segments together, was torn at a lumbar branch	Post-mortem exam : duo-jejunal transection, small bowel lacerations, partial transection transverse colon with abdo contamination, L2 body fracture	**Laparotomy**, **55 min post–accident** : Central haematoma over infrarenal aorta à cardiac arrest		Deceased during operation	Deceased during operation
Scharrer-Palmer 1998 (*27*)	25	Motorcycle accident (pillon rider)	**Terminal abdominal aorta**	Intracerebral haemorrhage, blunt chest trauma with bilateral pneumothorax, ruptured liver and spleen, lacerations to gastric wall + small bowel + colon, haematuria, retroperitoneal haematoma		**D+ 6 post-accident (interhospital transfer)** **Abdo-CT** : massive retroperit. haematoma + contrast enhancement dorsal to infrarenal aorta **Angiography** : haemorrhage from terminal aorta into retroperitoneum	Transfemoral self-expanding covered stent (no surgical repair because of risk of contamination from bowel lacerations)	Uneventful
Inaba *et al* 2001 (*10*)	52	Compression by industrial metal press	**Retrohepatic** aortic + caval lesion	Multiple rib fractures + bilateral haemo / pneumothorax, left scapulothoracic dissociation, multiple fractures left upper extremity, open fractures both lower limbs, hyperextension injury at T5/6 and T11	**DPL** : negative **USS** : negative	During **Thoracotomy**, intra-abdominal haemorrhage decompressing from posterior edge of diaphragm **à Thoraco-abdominal incision.** Active bleeding from retrohepatic aortic + caval lesion	(Surgical repair) (Definitive fixation of spinal fractures not performed)	Deceased in ICU 6 weeks later from respiratory complications
Rosengart *et al* 2002 (*25*)	66	Motor vehicle collision	Pseudoaneurysm extending anterolaterally from an aortal rupture **inferior to right renal artery**			**H+12 (interhospital transfer)** **Abdo-CT** : periaortic haematoma + active contrast extravasation	Infrarenal aorta decalcification + Dacron tube graft	Uneventful

Table II. — Published paediatric cases of blunt aortic disruption

Author / Study	**Age**	**Mechanism of Injury**	**Level of aortic Injury**	**Associated injuries**	**Early assessment of aorta**	**Late / Secondary assessment of aorta**	**Treatment of aortic lesion**	**Aortic outcome**
Wilson CH 1974 (*34*)	12	Horse-riding, horse fell on him	**Posteriorly,** at level of **bifurcation, extending into iliac vessels Thrombus** was blocking r. common iliac artery	Comminuted fracture of right iliac bone Pulseless right leg	Right femoral retrograde aortogram, 1hour after admission. Laparotomy 2 hours after admission.		Bifurcation graft Thrombus removal with Fogarty catheter (on the right)	Uneventful
Levien & Chleboun 1983 (*11*)	17	Motorcycle racing ; cycle landed on abdomen	Total disruption of abdom. aorta **0.5 cm distally to right renal artery** (1cm of the circumference remained intact)	3 cm laceration of inferior vena cava. Intimal injury of left renal artery. Avulsion of aorta from upper 3 pairs of lumbar arteries. Serosal tears of duodenum and terminal ileum. Falciform ligament tear	**Consecutive transfers from 2 hospitals →** **Laparotomy** : Total disruption of aorta		Surgical repair of aortal and arterial lacerations (interrupted sutures)	Uneventful
Tracy *et al* 1996 (*30*)	13	Bicycle fall, thrown on handlebar	Aortic tears at **aortic bifurcation + origin of renal arteries** Lumbar artery avulsion **<u>Post-mortem</u>** : **Infrarenal circumferential rupture**,intact arterial repairs, (Histo : no collagen or vessel abnormalities)	Epidural haematoma	Craniotomy **DPL** : positive → **Laparotomy** : aorta cross clamped at oesophageal hiatus and explored		Arterial repairs (sutures and sutures+Teflon pledgets for the bifurcation) (Thorough investigation of retroperitoneum and abdomen)	Cardiac arrest 30 min after transfer to ICU
Fox *et al* 1996 (*6*)	16 months	? child abuse	Aortic transection **immediately below origin of inf. mesenteric artery**, Ischaemic sigmoid colon, lacerated inf. vena cava	L3 body fracture	**Urgent laparotomy**		End-to-end aortic anastomosis	Uneventful

ICU = Intensive Care Unit.

Harkin *et al* 1999 *(9)*	7	Crushed by horizontal bar of a goal post	Left anterolateral laceration of aorta, **just above bifurcation** + disruption of left common iliac artery (Histo : no collagen or vascular disease)		Admitted in A&E Dept. 30 min post-accident **Abdo-CT** : aortic rupture just above the bifurcation + retroperitoneal haematoma	**Laparotomy** (performed at another trauma centre) Despite rapid control of aorta at diaphragmatic hiatus → cardiac arrest	Per-operative cardiac arrest	Per-operative cardiac arrest
Roth *et al* 1997 *(26)*	16	Restrained back-seat passenger	**Infrarenal** abnormalities and aortic transection	L2-L3 neurological deficit, fracture post. elements L3-L4, fracture R tib/fib, jejunal perforation, superior mesenteric vein tear	**Incidental finding** at **lumbar MRI** of irregular appearance aorta at L3 level	**D+2** **Arteriogram**	Axillo-femoral bypass (risk of contamination from bowel leak). Aortic continuity restored 9 months later	Uneventful
Lin *et al* 2003 *(12)*	6	Thrown from an all-terrain vehicle ; vehicle flipped over and landed on abdomen	Aortic rupture **just above bifurcation** + r. common iliac artery avulsion from the bifurcation. Haematoma between retroperitoneal pleura and aortic adventitia	Umbilical abrasion	**Abdo-CT** : contrast extravasation in retroperitoneum. **Aortogram** : distal aortic rupture. Air transferred → **laparotomy**		End-to-side ilioiliac bypass + aortic repair with patch angioplasty using R hypogastric artery (interrupt. sutures)	Uneventful
Muniz & Haynes 2004 *(19)*	8	Lap-belt restrained back seat passenger	**Infrarenal** aortic transection	Facial lacerations, left maxillary + nasal fractures, horizontal abdo wall contusion, small bowel disruption, partial transsection of lower rectus muscle, lumbar Chance's fracture, lumbosacral neuropathy (compressive retroperiton. haematoma) Abdo USS : intraperitoneal fluid in pelvis (CT of aorta + organs : OK)	**Laparotomy** : intact aorta, no retroperitoneal haematoma	**D+1** Hypotension + Tachycardia → **USS** : distal aortal pseudoaneurysm. **Laparotomy** : retroperitoneal haematoma, aortic transsection	Gore-Tex graft	Uneventful

Localisation

Most of the abdominal aortic injuries (92%) occur on the infrarenal part, followed by the area of insertion of the inferior mesenteric artery (*26*), the suprarenal aorta being relatively protected by the rib cage. Only one of the blunt abdominal aortic ruptures reviewed in the current study was located in the suprarenal region (retrohepatic) (*10*).

Mortality

The mortality rate of patients reaching the hospital alive ranges between 18% and 37% (*13, 17, 23, 24*). Early mortality is usually due to associated injuries, haemorrhage, mesenteric and peripheral embolisation, renal failure, myocardial ischaemia and cardiogenic shock (*20*). In fatal accidents, death frequently occurs abruptly by complete aortic disruption at the site of the accident or within one hour of the injury (*33*). Those who reach the Emergency Room are usually polytrauma patients and their injuries are distracting, making diagnosis of a ruptured aorta extremely difficult.

Mechanism

Direct forces applied to the aortic wall (compression of the vessel against the vertebral column by an external non-yielding object) can result in simple contusion, intimal dissection, intramural haematoma, thrombosis, pseudoaneurysm or frank rupture of the aorta (*19*) either from the resultant pressure or from associated thoracolumbar fractures causing laceration of the vessel (*6, 24*). In case of *indirect forces*, the aortic wall is stretched and compressed against a high-pressure column of blood. The elevated pressure above the injury causes intimal tear, pseudoaneurysm, rupture or thrombosis of the aorta (*19*). Deceleration forces leading to shearing of the aortic wall have also been described as indirect forces (*4, 24, 31*). It is noteworthy that in order to achieve total rupture of the aorta, forces in excess of 1,000 – 25,000 mm Hg are required (*6*). Atheromatous aortic plaques are believed to contribute to the aortic wall dissection : the intima becomes weaker by loss of elasticity and compliance of the aortic wall (*1, 26*). Aortic calcification was found in one of the reported cases of blunt abdominal aortic rupture (*24*). However, no such risk factor was present in the authors' case.

Clinical picture

For the diagnosis of these injuries a high level of suspicion, medical knowledge and information about the circumstances of the accident are essential. Seat belt use has the unique sign of a transverse ecchymotic abdominal wall band (seat-belt sign), and is frequently associated with abdominal wall transsection, bowel perforation, and lumbosacral spine fracture (*7, 19*). According to a review study on blunt injuries of the abdominal aorta by Roth *et al* (*26*), acute arterial insufficiency is the most common *early* (objective) sign (81%). Other early signs include acute abdomen (55%), paresis/paralysis (47%), abdominal wall contusion (24%), paraesthesia (20%) and abdominal wall defect (19%). The most common early (subjective) symptoms are : abdominal pain (92%), back pain (31%), numbness (22%), weakness of lower limbs (17%) and unconsciousness (14%). In *delayed* patient presentation, the predominant signs include abnormal peripheral pulses (52%), abdominal mass (43%) and abdominal bruit (33%). The symptoms in delayed presentations include : claudication (28%), abdominal pain (9.5%), back pain (5%), numbness (5%), weakness (4.5%) and impotence (2%).

Aortic transsection without any external signs is extremely rare, whereas fracture of the pelvis is common (*20*). Moreover, a direct aortic blunt trauma rarely leads to retroperitoneal haematoma (*8, 14*), while it is classical after fracture of the pelvis. The rare patients with an aortic lesion may seldom have, at operation, the same findings as those with a pelvic fracture, namely a retroperitoneal haematoma, which means that the aortic lesion is easily missed. If an aortic rupture is suspected, the aorta should be cross-clamped and retroperitoneal exploration should be performed (*20*). Retroperitoneal exploration is usually not performed when the haematoma is apparently due to the

pelvic fracture, which was the reasoning in the authors' case. The combination of clot formation at the injury site and the tamponade effect of the retroperitoneum can probably hamper an early diagnosis of aortic rupture. Clinical signs related to hypovolaemia by haemorrhage will become obvious when the clot will start to lyse (*28*). The adventitia being more resistant to rupture than the intima and media, fatal haemorrhage may occur when a subadventitial haematoma cannot be maintained by the adventitia (*12*).

Neurologic deficiencies associated with blunt abdominal aortic injuries range from distal anaesthesia to paralysis of both lower extremities, due to aortic occlusion, distal embolisation, anterior spinal artery syndrome (Adamkiewicz artery) or associated vertebral fracture with direct spinal cord injury. Spinal cord ischaemia with paraplegia occurs in 10% of the cases reported in the literature (*1*). In cases where paraplegia is associated, the MRI scan can detect ischaemic zones in the spinal cord (*1*). The neurologic deficit associated with the abdominal visceral injuries can frequently overshadow the diagnosis of an intra-abdominal vascular injury (*19*).

Diagnostic modalities

In haemodynamically stable patients with impaired lower extremity perfusion, angiography is the "gold standard" diagnostic tool for most of the trauma centres (*18, 19, 26*). The conjunction of contrast-enhanced CT scan and angiography can diagnose most of the aortic blunt injuries. Their conjunction can reduce the error margin in cases of thrombosed false lumen, atherosclerotic aneurysm, or presence of blood flow in both true and false lumen (*1*). Intraoperative ultrasonography or intraluminal ultrasonography have also been used to locate the injury (*20, 32*). All victims of a blunt trauma, powerful enough to cause thoracolumbar or pelvic fracture, even after a negative abdominal ultrasound scan (knowing that USS has poor sensitivity for retroperitoneal injuries), should have a contrast-enhanced abdominal CT-scan (*10*).

Delayed diagnosis

A high rate (34% to 36%) of delayed diagnosis is reported in the literature, related to hidden vascular symptomatology (52%) or to the emergency-related visceral lesions (*29*). Cases have been described where infrarenal aortic pseudoaneurysms or aortic ruptures with normal contrast-enhanced CT-scans had a delayed presentation and were diagnosed after a secondary CT-scan (*19, 22*). In the authors' case the injury was not evident on the initial CT-scan (presence of large retroperitoneal haematoma).

Surgical repair of the injured aorta depends on the nature and extent of the injury. Aortic ruptures are usually treated by standard suturing techniques, anastomosis or grafts.

The *patient* reported here was the victim of a rare mechanism of blunt abdominal aortic injury (compression) associated with a severe pelvic fracture and hip dislocation. The severity of this pelvic injury with the important retroperitoneal haematoma, the absence of active bleeding during the laparotomy and the haemodynamic stability, after external pelvic stabilisation (and throughout the hospitalisation), were not suggestive of any ongoing arterial active bleeding. The conjunction of ipsilateral sacroiliac joint disruption and hip dislocation with presence of unilateral anaesthesia of the leg have overshadowed an aortic aetiology for this neurological deficit, particularly since the distal pulses were found normal and symmetrical. The urgent assessment of the abdomen by laparotomy and the haemodynamic stability throughout the hospitalisation did not indicate the performance of a delayed contrast-enhanced-CT-scan and aortography. The delayed dramatic deterioration of this rare traumatic condition could be explained either by the fact that the clotted retroperitoneal haematoma started to lyse a few days after the accident or by a delayed rupture of the adventitia or a combination of these mechanisms.

CONCLUSION

The authors would suggest that whenever there is a high index of suspicion (lap-type seatbelt injuries for instance) of abdominal aortic injury,

angiography and CT-scan should be performed before hospital discharge. In addition, surveillance should include physical examination, Doppler ultrasound scan and CT-scan at appropriate time intervals indicated by the patient's condition (*1*).

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