Quel apport de la cartographie dans l'ablation conventionnelle ?

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DÉCLARATION DE LIENS D'INTÉRÊT POTENTIELS

Intervenant : Soufia Naccache, MLV

☑ Je n'ai pas de lien d'intérêt potentiel à déclarer

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Introduction

- Ablation conventionnelle ou guidée par la fluoroscopie :
  - Une question d'habitude, ça marche
  - Coût
- Qu'apporte la cartographie 3D par rapport à la stratégie conventionnelle ?
- Surcoût ?
- Adopter la cartographie de manière systématique?

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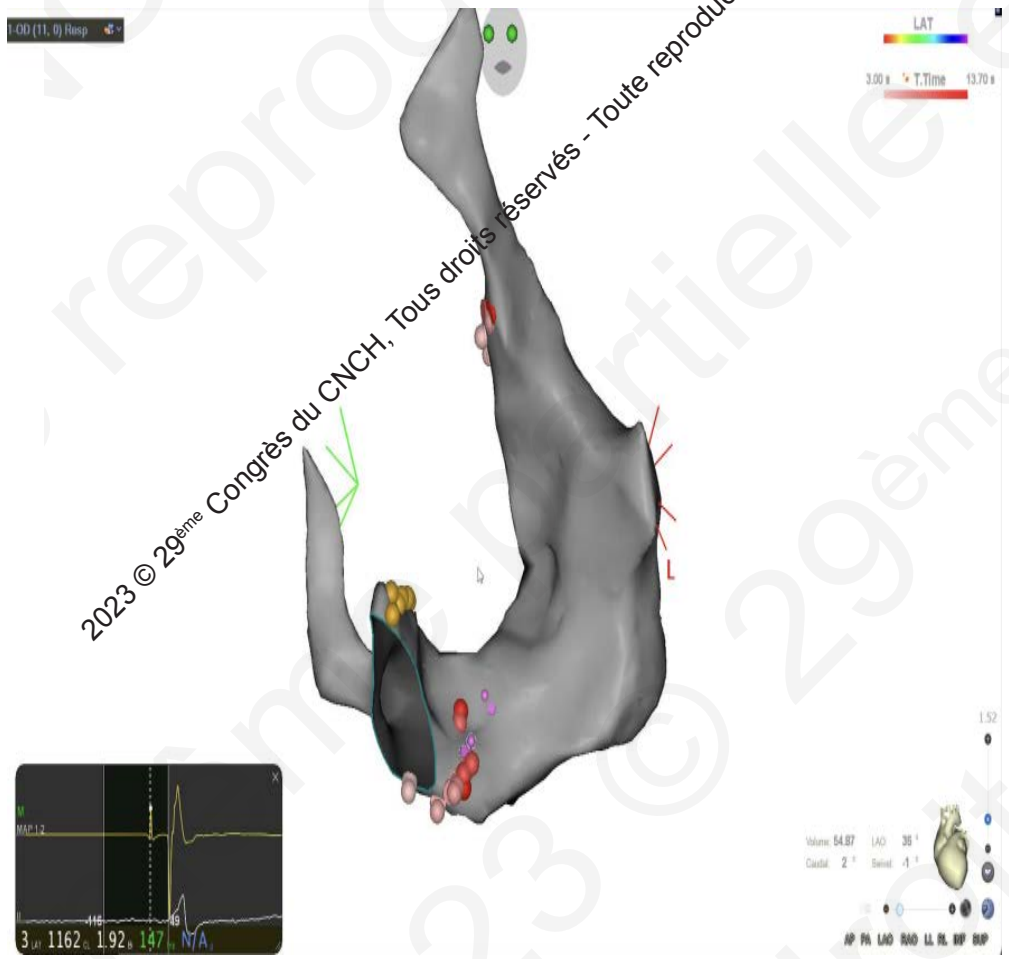
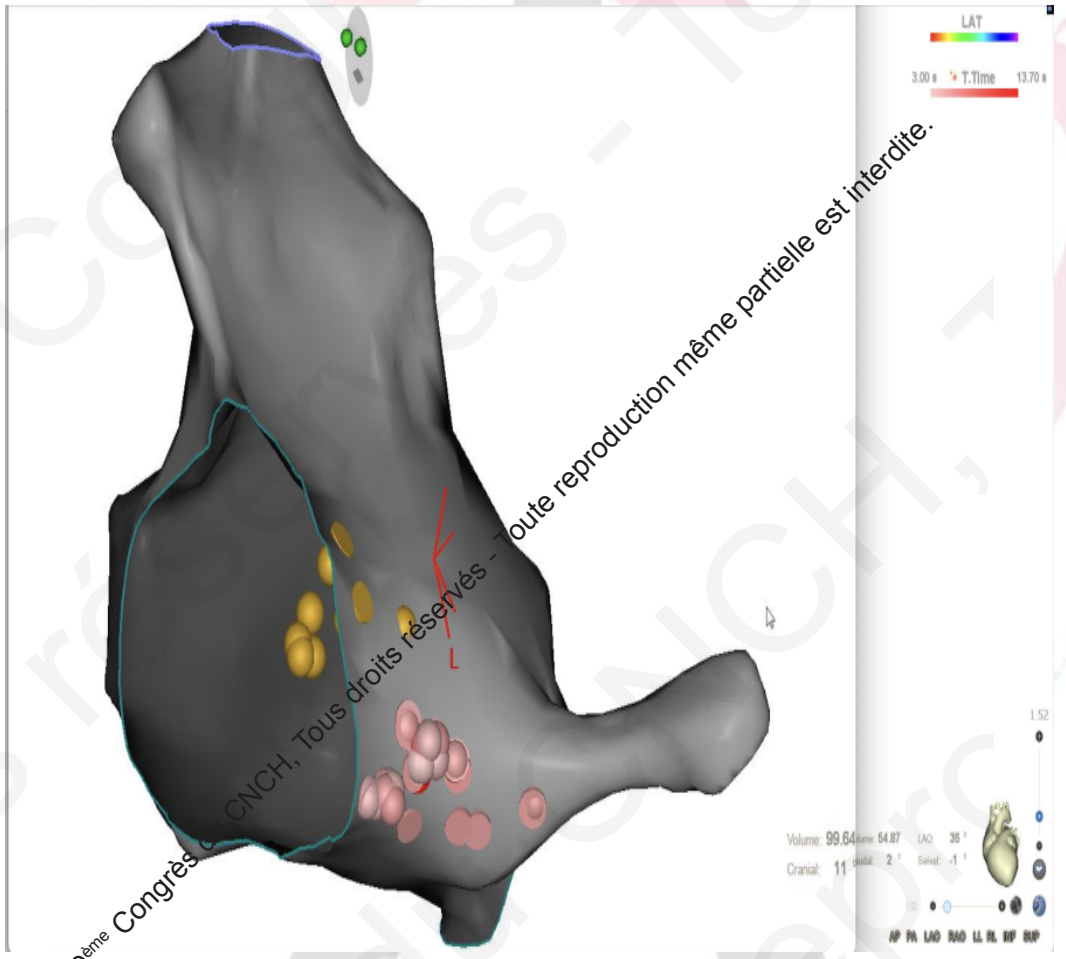
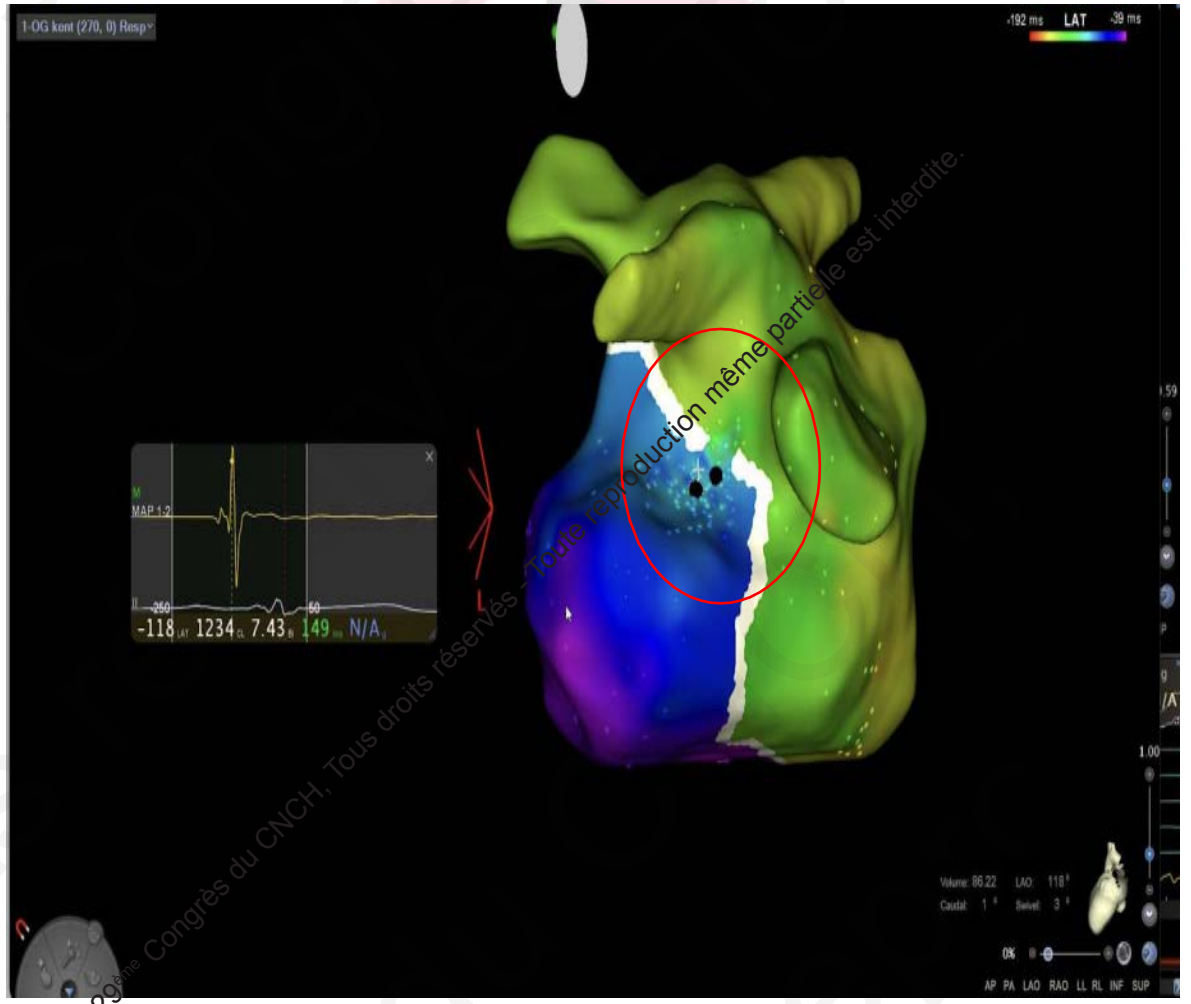
Cartographie 3D : Ablation de RIN





Cartographie 3D : Ablation de VA



Cartographie 3D: Exposition aux rayons X

TABLE V Comparative Radiation Exposure: Effective Dose Equivalent (rems)

Arrhythmia ablation procedure	1.7
Recommended annual limit for radiation workers[14]	5.0
Average annual dose in United States[15]	0.3
Medical procedures	
Coronary angiography	1.2
Coronary angioplasty	2.2
Thallium-201 scan[16]	2.1
Technetium-99 radionuclide ventriculogram[16]	0.8

Radiation Exposure to Patients and Medical Personnel During Radiofrequency Catheter Ablation for Supraventricular Tachycardia

Bruce D. Lindsay, MD, John O. Eichling, PhD, H. Dieter Ambos, and Michael E. Cain, MD

- Etude prospective
- 108 patients
- Ablation de VA ou RIN
- Protocole classique

Cartographie 3D: Exposition aux rayons X

TABLE VI Risk of Fatal Cancer Attributable to Radiation from Fluoroscopy

Age (yr)	Gender	Fluoroscopy Time 1 Hour (%)	2 Hours (%)	3 Hours (%)	4 Hours (%)
1–14	Male	1:460 (1.0)	1:230 (1.9)	1:155 (2.9)	1:115 (3.9)
	Female	1:380 (1.2)	1:190 (2.3)	1:130 (3.5)	1: 95 (4.6)
15–34	Male	1:640 (0.7)	1:320 (1.4)	1:210 (2.1)	1:160 (2.8)
	Female	1:500 (0.9)	1:250 (1.8)	1:165 (2.7)	1:125 (3.6)
35–54	Male	1:980 (0.4)	1:490 (0.9)	1:325 (1.4)	1:250 (1.8)
	Female	1:1087 (0.4)	1:540 (0.8)	1:360 (1.2)	1:270 (1.6)
55–74	Male	1:1220 (0.4)	1:610 (0.7)	1:410 (1.1)	1:305 (1.4)
	Female	1:1520 (0.3)	1:760 (0.6)	1:510 (0.9)	1:380 (1.2)
All	Male	1:760 (0.6)	1:380 (1.2)	1:250 (1.8)	1:190 (2.3)
	Female	1:730 (0.6)	1:360 (1.2)	1:240 (1.8)	1:180 (2.4)

The chance of developing a fatal cancer induced by radiation is listed in the columns. Numbers in parentheses are the percentages of spontaneous fatal malignancies for that age and gender.

Radiation Exposure to Patients and Medical Personnel During Radiofrequency Catheter Ablation for Supraventricular Tachycardia

Bruce D. Lindsay, MD, John O. Eichling, PhD, H. Dieter Ambos, and Michael E. Cain, MD

TABLE IV Radiation Dose to Adult Patient

Organ/Tissue	Dose Equivalent (rems)
Lungs	6.9
Breasts	2.0
Testes	<0.8
Ovaries	0.4
Thyroid	0.4
Bone marrow	1.1

Effective dose equivalent = 1.7 rems.

Cartographie 3D: Exposition aux rayons X

RESEARCH ARTICLE

Catheter Ablation of Right-Sided Accessory Pathways in Adults Using the Three-Dimensional Mapping System: A Randomized Comparison to the Conventional Approach

Table 1. Baseline and electrophysiological characteristics for patients in the conventional and 3D groups.

Baseline characteristics	Conventional	3D	P
Number of patients	31	33	N/A
Male/Female	19/12	21/12	0.846
Age (years)	37.7±8.7	33.6±7.3	0.127
Weight (kg)	59.5±7.6	60.1±7.8	0.778
Left ventricular ejection fraction (%)	74.5±5.1	72.9±6.2	0.259
Right atrium diameter (mm)	44±6	47±7	0.114
Underlying heart disease			
Congenital heart disease	0	0	
Mitral valve prolapse	0	1 (mild)	
Coronary artery disease (n)	0	0	
Hypertension (n)	2	3	0.9999
Type of AVRT			
Manifest accessory pathways (n)	22	22	0.711
Concealed accessory pathways (n)	9	11	
Location of accessory pathways			
Anterior septum (n)	5	5	0.9999
Middle septum (n)	5	8	0.4529
Posterior septum (n)	8	7	0.714
Right ventricular free wall (n)	13	13	0.836

- Etude Prospective
- Randomisée
- 64 patients
- TJ sur VA droites

Yuedong Ma et al, Plos one, 2015

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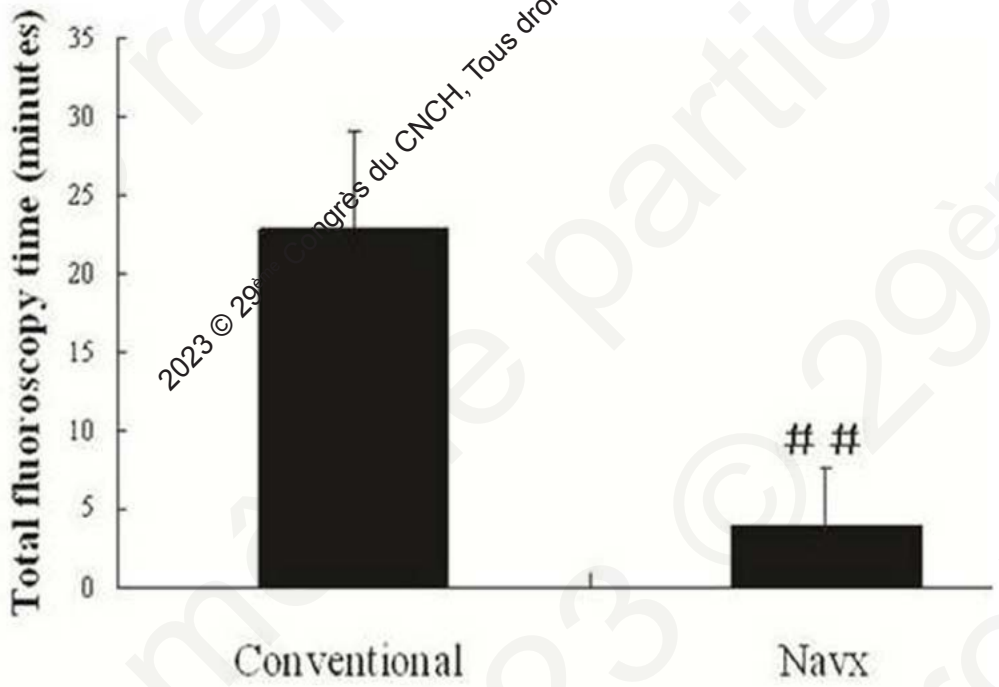
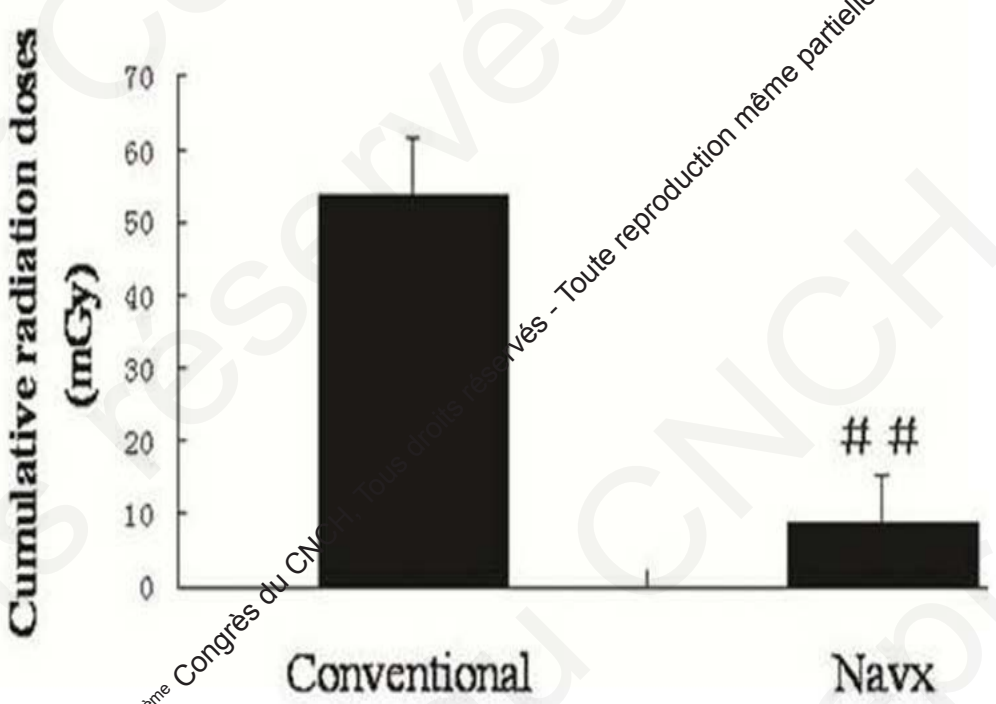
Cartographie 3D: Exposition aux rayons X

RESEARCH ARTICLE

Catheter Ablation of Right-Sided Accessory Pathways in Adults Using the Three-Dimensional Mapping System: A Randomized Comparison to the Conventional Approach

- Fig 2. Comparison of fluoroscopy exposure between the conventional and 3D (NavX) groups. ##$p<0.001$

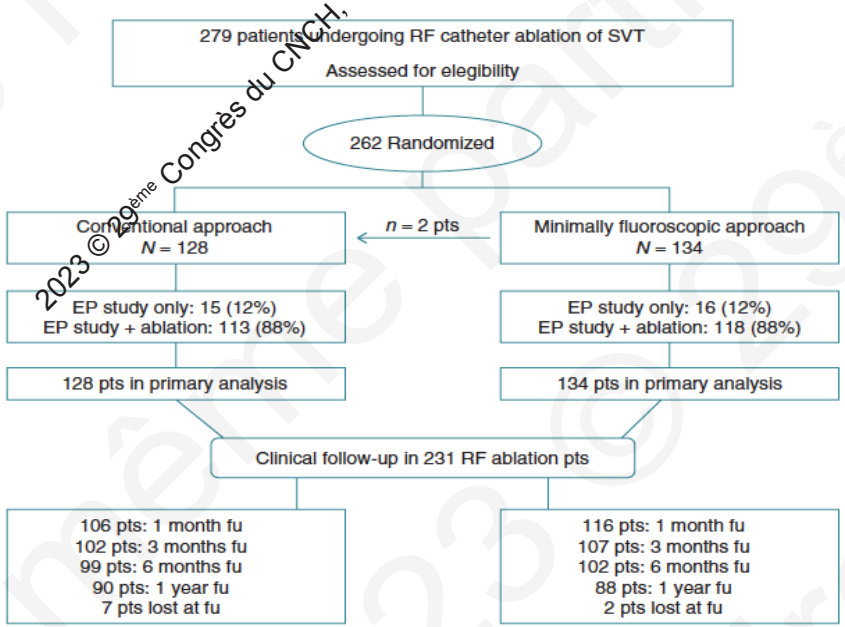




Yuedong Ma et al, Plos one, June 17, 2015

Cartographie 3D: Exposition aux rayons X

- Etude prospective
- Multicentrique, randomisée
- EnSite NavX
- 262 patients



Europace (2016) 18, 1565–1572
doi:10.1093/europace/euv344

CLINICAL RESEARCH
Cardiac electrophysiology

Near zerO fluoroscopic exPosure during catheter ablAtion of supRavenTricular arrhYthmias: the NO-PARTY multicentre randomized trial

Table 1 Demographic characteristics

	MFA *n* = 134	ConvA *n* = 128	*P*
Female, *n* (%)	79 (59)	73 (57)	ns
Age (years)	36.3 ± 10.4	35.4 ± 10.4	ns
BMI	24.4 ± 4.4	23.5 ± 4.4	ns
Previous ablation, *n* (%)	10 (8)	13 (10)	ns
EPS, *n* (%)	16 (12)	15 (12)	ns
AVNRT, *n* (%)	84 (63)	79 (62)	ns
Right AP, *n* (%)	10 (8)	11 (9)	ns
Left AP, *n* (%)	11 (8)	14 (11)	ns
AFl, *n* (%)	10 (8)	6 (5)	ns
AT, *n* (%)	3 (2)	3 (2)	ns

BMI, body mass index; EPS, electrophysiological study; AVNRT, atrioventricular node re-entry tachycardia; AP, accessory pathway; AFl, atrial flutter; AT, atrial tachycardia.

M. Casella et al, Europace, 2016

Cartographie 3D: Exposition aux rayons X

- <<< Fluoroscopie : 96% le risque d'incidence/mortalité liée au cancer et attribuable à la procédure.
- 1 ablation Conventionnelle = 1 semaine de perte de survie, 2 semaines de vie affectée (35 ans) , Femmes +++

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CLINICAL RESEARCH
Cardiac electrophysiology

Near zerO fluoroscopic exPosure during catheter ablAtion of supRavenTricular arrhYthmias: the NO-PARTY multicentre randomized trial

Table 2 Ionizing radiation data

	MFA	ConvA	*P*
All patients (*n* = 262)			
Fluoroscopy time (s)	0 [0–12]	859 [545–1346]	<0.00001
DAP (cGy cm^2)	278 [80–791]	2036 [854–5297]	<0.00001
ED (mSv)	0 [0–0.08]	8.87 [3.67–22.01]	<0.00001
Extrapolated ED (mSv)	0 [0–0]	3.96 [1.68–10.54]	<0.00001
Fluoro on pelvic area, *n* (%)	3/134 (2)	62/128 (48)	<0.0001

Extrapolated ED: ED extrapolated by the formula: mSv = DAP (Gy cm^2) × 0.20.
ED, effective dose; DAP, dose-area product.

Table 3 Lifetime attributable risks

LAR	Age	MFA		ConvA	
		Man	Woman	Man	Woman
Mortality	15	4.8 (2.5–8.2)	6.1 (3.9–9.2)	136 (82–215)	186 (131–265)
	25	4.0 (1.8–7.0)	4.7 (2.8–7.4)	105 (59–171)	138 (94–200)
	35	3.7 (1.6–6.5)	4.2 (2.4–6.7)	94 (51–156)	119 (79–175)
	45	3.7 (1.5–6.9)	4.1 (2.3–6.7)	94 (49–158)	115 (76–171)
Incidence	15	10.0 (6.0–18.6)	15.4 (9.9–25.3)	321 (198–512)	486 (333–773)
	25	8.4 (4.3–14.4)	10.9 (6.9–17.4)	236 (140–377)	335 (230–509)
	35	7.4 (3.6–12.9)	8.9 (5.5–14.0)	201 (117–324)	267 (183–393)
	45	7.3 (3.4–12.8)	8.2 (5.0–12.8)	195 (111–315)	241 (165–350)

Lifetime attributable risk of all cancers mortality and incidence, calculated according to BEIR risk models, with 95% confidence intervals from MFA (*N* = 134) and ConvA procedures (*N* = 128) in function of age at exposure and sex (number of cases in 100.000).

M. Casella et al, Europace, 2016

Cartographie 3D: Sécurité et efficacité

TABLE 1 Baseline patient characteristics

Variable	CF (n = 101)	EZF (n = 100)	CZF (n = 99)	Total (n = 300)	*P* value
Age, y, mean (SD)	46.9 (16.2)	46.7 (16)	37.8 (14.5)	45.3 (15.4)	<0.001
Weight, kg, mean (SD)	65 (6)	64 (6.2)	60.5 (4.8)	63.8 (11.7)	0.816
Height, cm, mean (SD)	167.6 (6.2)	166.9 (6.1)	162.4 (24.3)	164.9 (8.3)	0.327
Male sex	45 (44.1)	40 (40)	39 (39.6)	118 (39.3)	0.851
BMI, kg/m², mean (SD)	23.1 (4.1)	22.9 (4.2)	22.5 (5.2)	23 (7.1)	–
3D mapping, %	100	100	100	100	–
EPS only	0	4 (4)	3 (3)	7 (2.3)	–
Ablation	101 (100)	96 (96)	96 (96)	293 (97.7)	0.104
AVNRT	63 (62.3)	66 (56)	67 (67)	196 (65.3)	0.205
AVRT	37 (37)	34 (34)	33 (33)	104 (34.6)	0.363
Left free wall	16 (16)	19 (19)	18 (18)	53 (17.6)	0.864
Right free wall	9 (9)	7 (7)	8 (8)	24 (8)	0.882
Posteroseptal	11 (11)	6 (6)	6 (6)	23 (7.6)	0.328
Parahisian	1 (1)	2 (2)	1 (1)	4 (1.3)	0.848

The safety and efficacy of zero-fluoroscopy ablation versus conventional ablation in patients with supraventricular tachycardia

Alselmi Fadhle[1], Mei Hu[2], Yan Wang[1]

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- Etude prospective
- Randomisée en 3 bras : CF, EZF, CZF
- Carto 3D, EnSite NavX
- 299 patients

Alselsmi et al, Kardiologia Polska, 2020

Cartographie 3D: Sécurité et efficacité

TABLE 2 Comparison of the efficiency and safety of ablation in the study groups

Variable	CZF (n = 100)	EZF (n = 100)	CF (n = 100)
Procedure time, min, mean (SD)	65.4 (27.5)	66.5 (24.2)	61.8 (36.2)
Ablation time, s, mean (SD)[a]	320.4 (27.1)	306.5 (30.5)	341.7 (33.3)
Complete ZF[b]	99 (99)	100 (100)	NA
Give up[c]	0	1 (1)	0
Immediate success	99 (99)	99 (99)	100 (100)
Recurrence	0	0	1(1)

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Alselsmi et al, Kardiologia Polska, 2020

Cartographie 3D: Sécurité et efficacité

TABLE 3 Complications in the study groups

Complication	CZF (n = 100)	EZF (n = 100)	CF (n = 100)	Total (n = 300)
Mild-moderate	1	1	0	2
Pseudoaneurysm	1	1	0	2
Arterial-venous fistula	0	0	0	0
Pneumothorax	0	0	0	0
Hemothorax	0	0	0	0
Cardiac tamponade	0	0	0	0
Severe	0	0	0	0
II–III degree of AVB	0	0	0	0
Thoracic surgery	0	0	0	0
Total	1	1	0	2

The safety and efficacy of zero-fluoroscopy ablation versus conventional ablation in patients with supraventricular tachycardia

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Alselsmi et al, Kardiologia Polska, 2020

Cartographie 3D: Sécurité et efficacité

- Registre européen
- Multicentrique : 12 centre européens
- Protocole d'ablation
- Rhythmia HD

Minimal fluoroscopy approach for right-sided supraventricular tachycardia ablation with a novel ablation technology: Insights from the multicenter CHARISMA clinical registry

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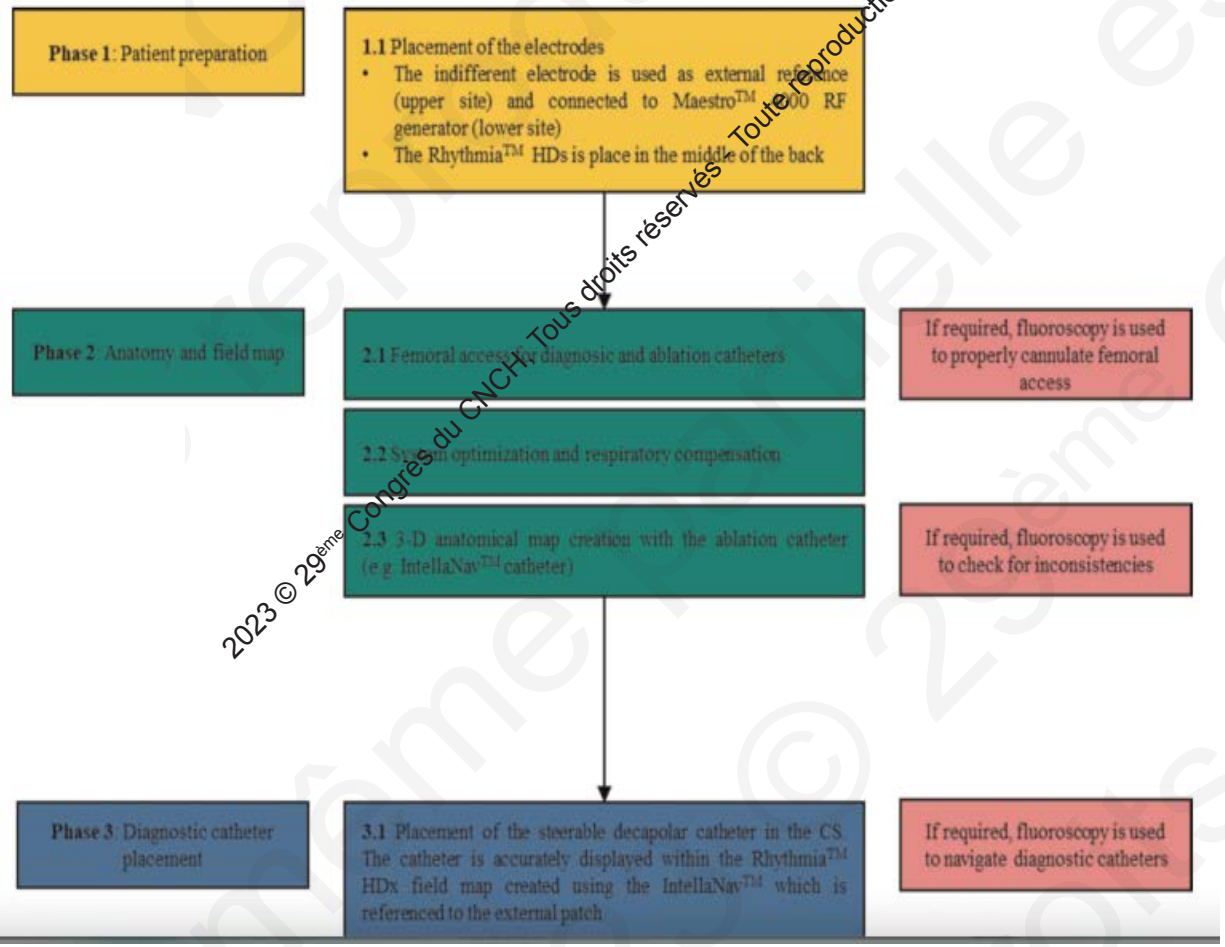
Cartographie 3D: Sécurité et efficacité



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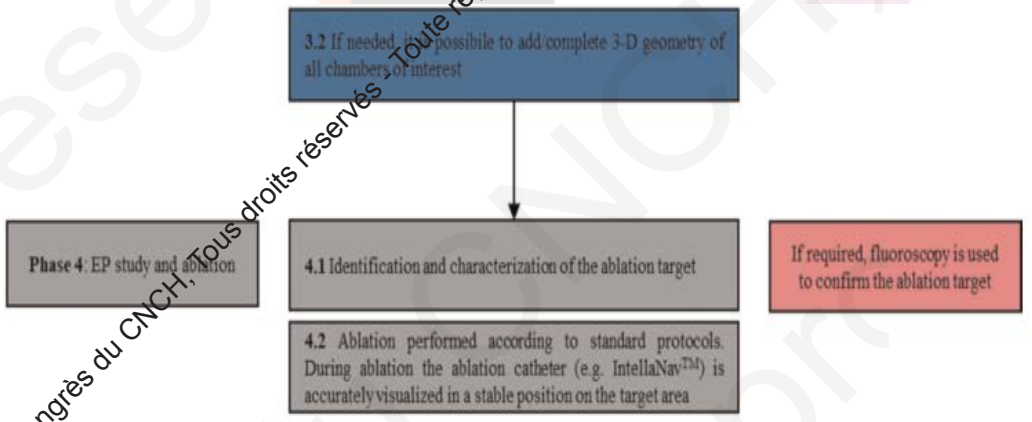
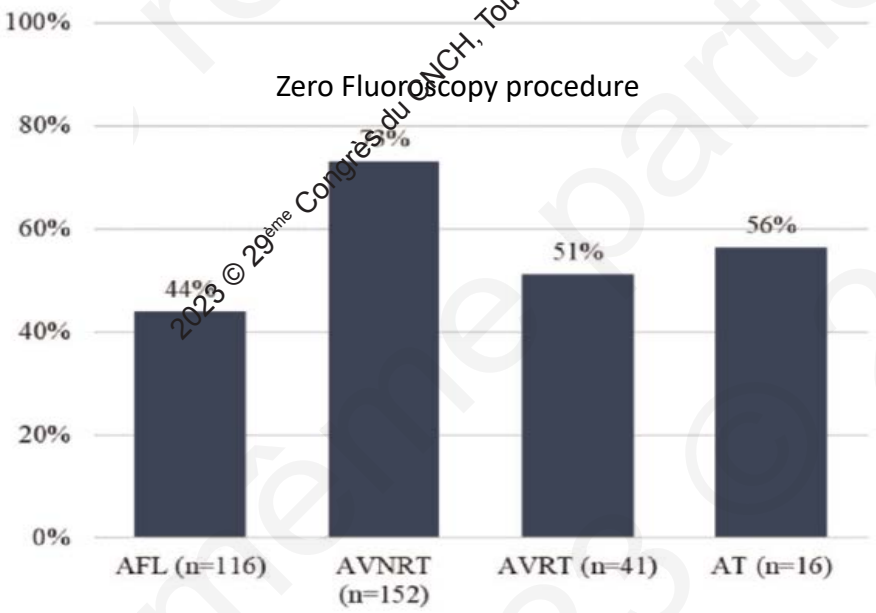


Cartographie 3D: Sécurité et efficacité

- 325 patients (AFL, AVNRT, AVRT, AT)
- Taux de Fluoroscopie < 2min
- Mapping < 15 min
- Temps de procédure < 20 minutes



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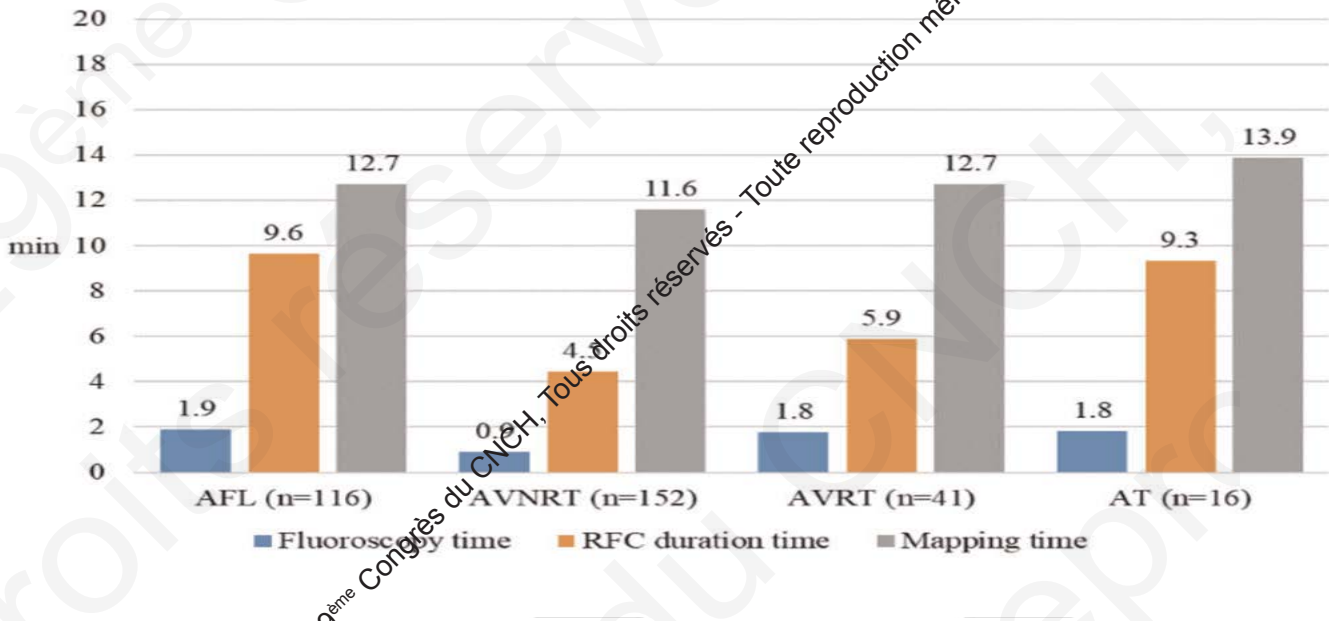


Cauti et al, J Cardiovasc Electrophysiol. 2021

Cartographie 3D: Sécurité et efficacité

TABLE 2 Univariate and multivariate factors associated with zero fluoroscopy achie

Variable	OR	95% CI	p
Femoral access guided by echography	1.4353	0.6711–3.0697	.3515
AVNRT[a]	3.075	1.9289–4.9021	<.0001
AVRT	0.6939	0.3597–1.3383	.2755
BMI	0.9755	0.9206–1.0275	.3206
COPD	0.6862	0.1685–2.7935	.599
CAD	0.6125	0.2294–1.6353	.3278
Structural heart disease	0.6799	0.3695–1.2512	.215
Patient's age	0.9983	0.9851–1.0118	.8078
Operator's age	0.9829	0.9562–1.0103	.2191
AFL[a]	0.3784	0.2372–0.6037	<.0001
Hypertension	0.7137	0.4234–1.2030	.2055
LVEF	1.0099	0.9715–1.0498	.6187
Valvular disease	0.2617	0.0803–0.8531	.0262
Operator's experience in EP procedures	1	0.9998–1.0003	.7264
Number of RF applications	0.9272	0.8998–0.9555	<.0001
Fellow in training during the procedure	0.1018	0.0343–0.3019	<.0001
Female gender	1.8757	1.1874–2.9632	.007
History of AF	0.657	0.3383–1.2758	.2147
AT	0.8852	0.3213–2.4390	.8136
RF application time	0.9983	0.9975–0.9990	<.0001
Mapping time	0.9995	0.9989–1.0000	.0451
Type of procedure (redo vs. de novo)	0.8723	0.3832–1.9858	.7448
Mapped volume	0.9966	0.9920–1.0011	.1397

Minimal fluoroscopy approach for right-sided supraventricular tachycardia ablation with a novel ablation technology: Insights from the multicenter CHARISMA clinical registry

Nombre de tirs RF
Temps d'application RF
Présence de Fellow

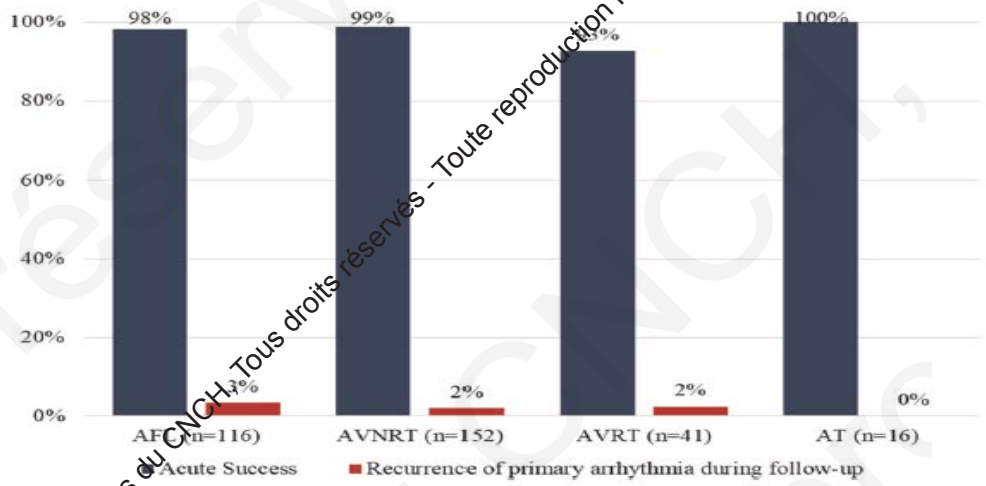
Facteurs prédictifs de Rx

Cartographie 3D: Sécurité et efficacité

TABLE 4 Acute and end of follow-up procedural outcome

Parameter	*n* = 325
Acute success, *n* (%)	318 (97.8)
Recurrence of the primary arrhythmia during follow-up, *n* (%)	8 (2.5)
Occurrence of other arrhythmias (beyond primary arrhythmia), *n* (%)	14 (4.3)
Major adverse events related to the procedures, *n* (%)	0 (0.0%)
Follow-up duration (days)	290.7 ± 169.6

Minimal fluoroscopy approach for right-sided supraventricular tachycardia ablation with a novel ablation technology: Insights from the multicenter CHARISMA clinical registry



Cartographie 3D: Sécurité, efficacité à long terme

TABLE 1 Baseline and Procedural Data

	MFA (n = 206)	ConvA (n = 412)	p Value
Female	124 (60.2)	248 (60.2)	1.00
Age, yrs	37.2 ± 14.6	37.9 ± 15.5	0.60
AVNRT	145(70.4)	290 (70.4)	1.00
Posteroseptal WPW	17 (8.2)	34 (8.3)	1.00
Left lateral WPW	19 (9.2)	38 (9.2)	1.00
Right lateral WPW	14 (6.8)	28 (6.8)	1.00
Left concealed AP	11 (5.3)	22 (5.3)	1.00
Fluoroscopy time, min	0.0 (0.0-1.0)	15.8 (9.2-23.8)	<0.001
DAP, Gy·cm^2	0 (0-80)	2,216 (1,206-4,458)	<0.001
Effective radiation dose, mSv	0.00 (0.00-0.16)	4.43 (2.41-8.92)	<0.001

Values are n (%), mean ± SD, or median (interquartile range). Discrete variables are presented as number and percentage (%).

AP = accessory pathway; AVNRT = atrioventricular nodal re-entrant tachycardia; ConvA = conventional fluoroscopic approach; DAP = dose-area product; MFA = minimal fluoroscopic approach; WPW = Wolff-Parkinson-White.

Long-Term Outcomes of Near-Zero Radiation Ablation of Paroxysmal Supraventricular Tachycardia

A Comparison With Fluoroscopy-Guided Approach

- Etude rétrospective
- Observationnelle
- Toutes les ablations (RIN et VA) : 2010 – 2015
- Comparaison : MFA Vs ConvA
- NavX, Carto 3D

Cartographie 3D: Sécurité, efficacité à long terme

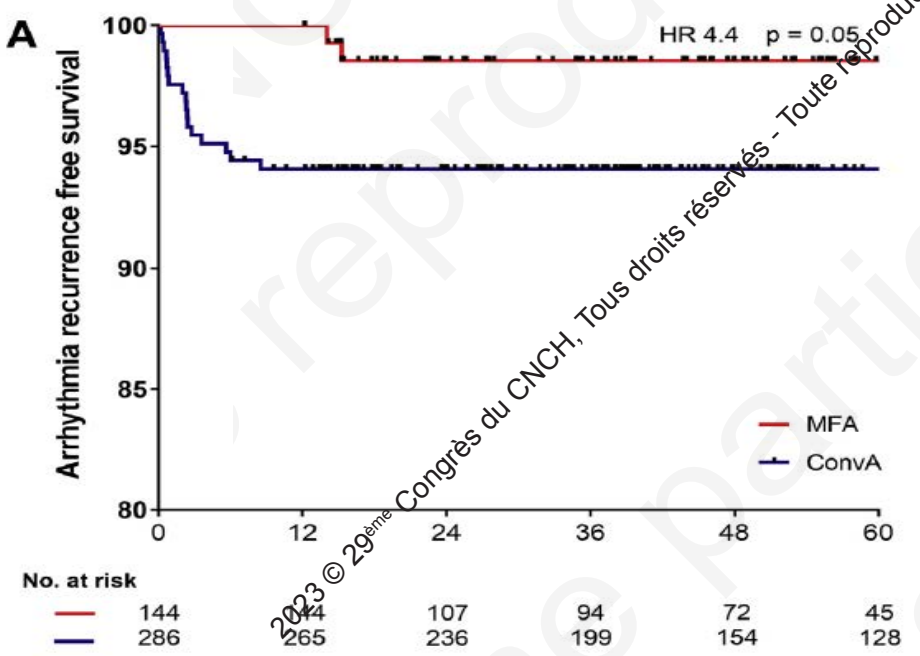
TABLE 2 Acute and Long-Term Outcomes

	MFA (n = 206)	ConvA (n = 412)	p Value
Acute			
Acute success	204 (99.0)	400 (97.1)	0.10
Acute complications	5 (2.4)	22 (5.3)	0.14
Patients requiring prolonged hospitalization	2 (1.0)	21 (5.1)	0.01
Days of hospitalization	2.05 ± 0.36	2.09 ± 0.49	0.04
Long term			
Months of follow-up	47.7 (22.6-63.3)	52.3 (32.4-75.4)	0.12
Long-term recurrence	5 (2.4)	37 (8.9)	//
Long-term complications	1 (0.5)	14 (3.4)	0.03
Pacemaker implantation	0 (0.0)	5 (1.2)	0.18
Permanent AV dysfunction	0 (0.0)	12 (2.9)	0.01

Long-Term Outcomes of Near-Zero Radiation Ablation of Paroxysmal Supraventricular Tachycardia

A Comparison With Fluoroscopy-Guided Approach

Cartographie 3D: Sécurité, efficacité à long terme



Atrioventricular nodal re-entrant tachycardia

Long-Term Outcomes of Near-Zero Radiation Ablation of Paroxysmal Supraventricular Tachycardia

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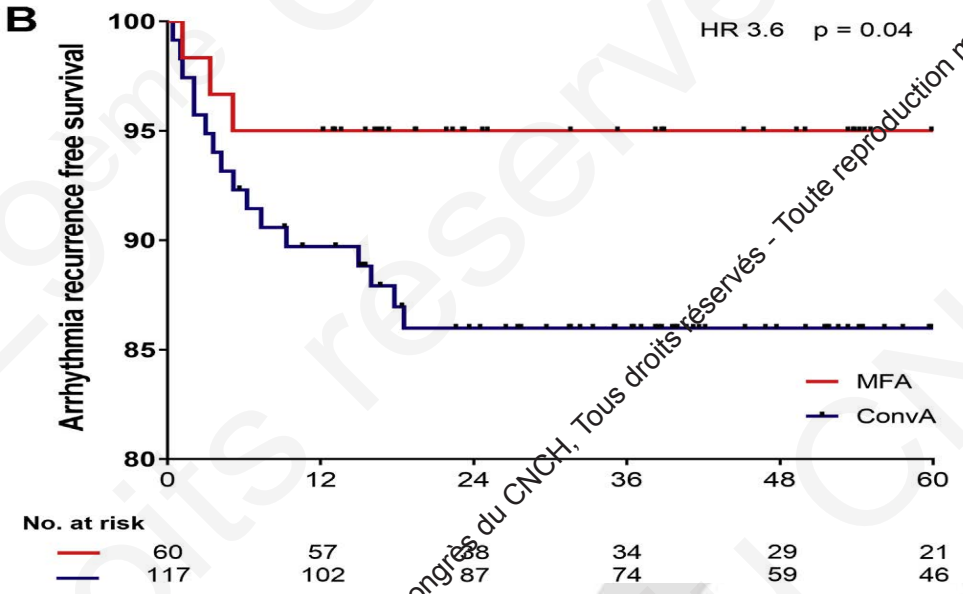

Atrioventricular re-entrant tachycardia.

Cartographie 3D: Surcoût

Europace (2016) 18, 1565–1572
doi:10.1093/europace/euv344

CLINICAL RESEARCH
Cardiac electrophysiology

Near zerO fluoroscopic exPosure during catheter ablAtion of supRavenTricular arrhYthmias: the NO-PARTY multicentre randomized trial

Economic considerations

The Health Technology Assessment evaluates medical technologies under clinical, ethical, organizational, and economic points of view to assess if they are worth being funded.[38,39]

The MFA clearly produces clinical benefits for both patients and medical staff as it decreases the risk of cancer due to radiation exposure. It may be argued that avoiding patients' risks for unrelated diseases and protecting medical staff in its professional environment deserve a higher priority. From a strictly economic perspective, the crucial issue is whether MFA in ablation is affordable given the constraints in available resources. This study does not provide enough data to conduct a cost-effectiveness analysis, but it gives robust evidence in terms of increase in life expectancy and in period of life free

- Surcoût : 1100 – 1900 Euros
- Pas d'étude dédiée
- Surcoût amorti par une meilleure survie totale et sans cancer

M. Casella et al, Europace, 2016

Cartographie 3D: Quel système ?

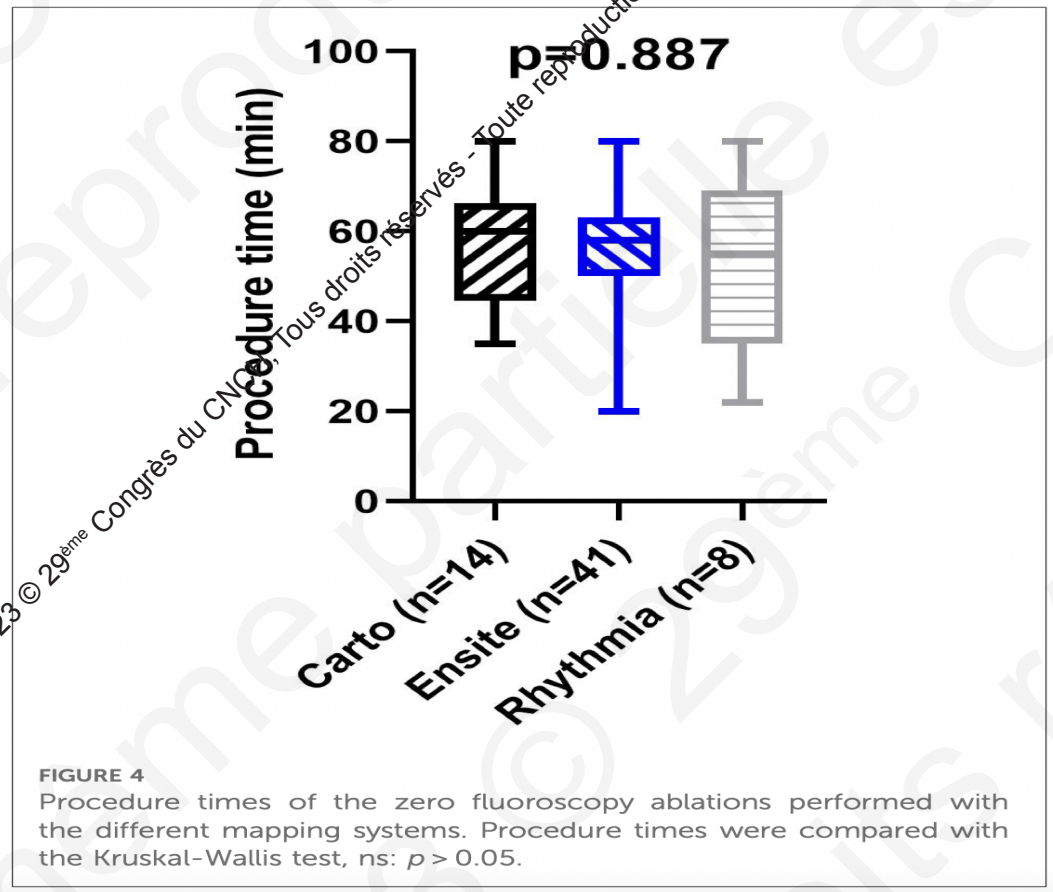

FIGURE 4
Procedure times of the zero fluoroscopy ablations performed with the different mapping systems. Procedure times were compared with the Kruskal-Wallis test, ns: $p > 0.05$.

Zero fluoroscopy ablation for atrioventricular nodal reentrant tachycardia and typical atrial flutter is equally safe and effective with EnSite NavX, Carto3, and Rhythmia mapping systems

- Faible effectif
- Etudes à venir ?

Viros et al, Frontiers in Cardiovascular Medicine July 2023

Cartographie 3D: Pour qui?

2019 APHRS expert consensus statement on three-dimensional mapping systems for tachycardia developed in collaboration with HRS, EHRA, and LAHRS

Use of 3D mapping in supraventricular tachycardias	
Recommendation	**Class**
In pediatric patients or pregnant patients undergoing SVT ablation, the use of a 3D mapping system is recommended to reduce radiation exposure to a minimum and to reduce the risk of complications such as total AV block.	I
In patients with midseptal or parahisian pathways undergoing SVT ablation, the use of a 3D mapping system is recommended to reduce radiation exposure and to reduce the risk of complications such as total AV block.	I
The use of a 3D mapping system is reasonable for redo ablation procedures or cases with impaired catheter stability (eg, right-sided free-wall pathways), after catheter dislodgement during ablation (eg, due to tachycardia termination) or when consecutive mapping from different anatomical sites (eg, atrium, ventricles, coronary sinus, aortic root) is performed to facilitate the ablation procedure, to better understand the anatomy to reduce procedure duration and radiation exposure for both the patient and the operator.	IIa
For localizations of APs with lower success and higher recurrence rates, such as right-sided APs, it is reasonable to use 3D mapping system to reduce procedure and fluoroscopy time.	IIa

Young-Hoon et al, Journal of Arrhythmia. 2020

Conclusion

Apport de la cartographie dans l'ablation conventionnelle :

- <<<< Rayons X
- Moins de complications
- ≥ Efficacité
- Surcoût relatif

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