Convegno Nazionale sulla tutela della salute e della sicurezza nei luoghi di lavoro

Quartiere Fieristico di Bologna

Giovedì 17 ottobre 2019

CEM: le condizioni che possono comportare una maggiore suscettibilità dei lavoratori e le misure di prevenzione

UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Prof. Fabriziomaria Gobba,
Dr. Alberto Modenese

Cattedra di Medicina del Lavoro

Regione Emilia-Romagna
Assessorato politiche per la salute

INAIL

CONVEGNO NAZIONALE

d-A2019

Agenti fisici e salute nei luoghi di lavoro

Bologna - Giovedì 17 ottobre 2019
Nell'ambito di AMBIENTE-LAVORO 2019 – QUARTIERE FIERISTICO DI BOLOGNA
INGRESSO Piazza della Costituzione - Sala Rossini - Ammezzato Padiglioni 21/22
Salone Nazionale della Salute e Sicurezza nei Luoghi di Lavoro

“Lavoratori particolarmente sensibili al rischio (da CEM)”

- ***Definizione introdotta dall’art. 209 D.Lgs 81/2008 (art. 4 Direttiva 2013/35/EU)***

Quali rischi sono presi in considerazione dalla normativa:

1. Il presente capo determina i requisiti minimi per la protezione dei lavoratori contro i rischi per la salute e la sicurezza derivanti dall'esposizione ai campi elettromagnetici (da 0 Hz a 300 GHz), come definiti dall'articolo 207, durante il lavoro. Le disposizioni riguardano la protezione dai rischi per la salute e la sicurezza dei lavoratori dovuti agli effetti biofisici diretti e agli effetti indiretti noti provocati dai campi elettromagnetici. (Art. 206, comma 1)

Articolo 207: Definizioni

b) effetti biofisici diretti effetti provocati direttamente nel corpo umano dalla presenza di un campo elettromagnetico, che comprendono:

1) ***effetti termici***
2) ***effetti non termici (stimolazione di muscoli, nervi e organi sensoriali)***
3) ***correnti negli arti***

c) effetti indiretti effetti provocati dalla presenza di un oggetto in un campo elettromagnetico, che potrebbe essere causa di un pericolo per la salute e sicurezza, quali:

1. ***interferenza con attrezzature e dispositivi medici elettronici, compresi stimolatori cardiaci e altri impianti o dispositivi medici portati sul corpo***

   ……

5. ***correnti di contatto***

Quali rischi sono presi in considerazione dalla normativa:

1. Il presente capo determina i requisiti minimi per la protezione dei lavoratori contro i rischi per la salute e la sicurezza derivanti dall'esposizione ai campi elettromagnetici (da 0 Hz a 300 GHz), come definiti dall'articolo 207, durante il lavoro. Le disposizioni riguardano la protezione dai rischi per la salute e la sicurezza dei lavoratori dovuti agli effetti biofisici diretti e agli effetti indiretti noti provocati dai campi elettromagnetici. (Art. 206, comma 1)

2. I Valori limite di esposizione (VLE) stabiliti nel presente capo riguardano soltanto le relazioni scientificamente accertate tra effetti biofisici diretti a breve termine ed esposizione ai campi elettromagnetici (Art. 206, comma 2).

Quali rischi sono presi in considerazione dalla normativa:

1. Il presente capo determina i requisiti minimi per la protezione dei lavoratori contro i rischi per la salute e la sicurezza derivanti dall'esposizione ai campi elettromagnetici (da 0 Hz a 300 GHz), come definiti dall'articolo 207, durante il lavoro. Le disposizioni riguardano la protezione dai rischi per la salute e la sicurezza dei lavoratori dovuti agli effetti biofisici diretti e agli effetti indiretti noti provocati dai campi elettromagnetici. (Art. 206, comma 1)

2. I Valori limite di esposizione (VLE) stabiliti nel presente capo riguardano soltanto le relazioni scientificamente accertate tra effetti biofisici diretti a breve termine ed esposizione ai campi elettromagnetici (Art. 206, comma 2).

3. Il presente capo non riguarda la protezione da eventuali effetti a lungo termine e i rischi risultanti dal contatto con i conduttori in tensione (Art. 206, comma 3)

Direttiva 2013/35/UE

Preambolo:

(7) This Directive does not address suggested long-term effects of exposure to electromagnetic fields, **since there is currently no well-established scientific evidence of a causal relationship**

Tabella 11.1 — Effetti e sintomi associati a un'esposizione superiore ai VLE relativi agli effetti sanitari

Campo	Frequenza	Possibili effetti e sintomi
Campi magnetici statici	0-1 Hz	Interferenza con dispositivi medici Nausea e vertigini. Effetti su flusso ematico, battito cardiaco, funzione cerebrale (possibile al di sopra di 7 T) Stimolazione dei nervi e contrazione dei muscoli (movimenti rapidi)
Campi magnetici a bassa frequenza	1 Hz-10 MHz	Interferenza con dispositivi medici Sensazioni visive Stimolazione nervosa, con conseguente formicolio o dolore Contrazione dei muscoli, aritmia cardiaca
Campi elettrici a bassa frequenza	1 Hz-10 MHz	Scosse elettriche e ustioni superficiali (in caso di contatto con oggetti)
Campi ad alta frequenza	100 kHz e oltre	Interferenza con dispositivi medici Sensazione di calore Stress termico Scossa e ustione superficiale o profonda (in caso di contatto con oggetti) Possibilità di altri sintomi
I campi intermedi (100 kHz-10 MHz) producono un quadro misto, in cui compaiono i sintomi sia delle alte che delle basse frequenze		

da: "Guida non vincolante di buone prassi, Volume 1: Guida pratica." Unione Europea, 2015

Articolo 207: Definizioni

d) «valori limite di esposizione (VLE)», *valori stabiliti sulla base di considerazioni biofisiche e biologiche, in particolare sulla base degli* ***effetti diretti acuti e a breve termine scientificamente accertati, ossia gli effetti termici e la stimolazione elettrica dei tessuti;***

e) «VLE relativi agli effetti sanitari», *VLE al di sopra dei quali i lavoratori potrebbero essere soggetti a* ***effetti nocivi per la salute, quali il riscaldamento termico o la stimolazione del tessuto nervoso o muscolare;***

f) «VLE relativi agli effetti sensoriali», *VLE al di sopra dei quali i lavoratori potrebbero essere soggetti a* ***disturbi transitori delle percezioni sensoriali e a modifiche minori nelle funzioni cerebrali;***

Articolo 207: Definizioni

g) «valori di azione (VA)», *livelli operativi stabiliti per semplificare il processo di dimostrazione della conformità ai pertinenti VLE o, ove appropriato, per prendere le opportune misure di protezione o prevenzione specificate nel presente capo, nell'allegato XXXVI, parte II:*

1) *per i campi elettrici, per «**VA inferiori**» e «**VA superiori**» s'intendono i livelli connessi alle specifiche misure di protezione e prevenzione stabilite nel presente capo*

2) *per i campi magnetici, per «**VA inferiori**» s'intendono i valori connessi ai VLE relativi agli effetti sensoriali e per «**VA superiori**» i valori connessi ai VLE relativi agli effetti sanitari.*

Quali condizioni fisiologiche/patologiche comportano una “particolare sensibilità” al rischio da CEM?

Alcune espressamente citate nella normativa: “.. *in particolare soggetti portatori di dispositivi medici impiantati, attivi o passivi, o dispositivi medici portati sul corpo e le lavoratrici in stato di gravidanza*” (art. 209, comma 5, lett. d)

Una lista è riportata nella “Guida non vincolante di buone prassi”

“Lavoratori particolarmente sensibili al rischio”

Quali condizioni fisiologiche/patologiche?

Tabella 3.1 — Lavoratori particolarmente a rischio ai sensi della direttiva relativa ai campi elettromagnetici

Lavoratori particolarmente a rischio	Esempi
Lavoratori portatori di dispositivi medici impiantabili attivi (Active Implanted Medical Devices, AIMD)	Stimolatori cardiaci, defibrillatori cardiaci, impianti cocleari, impianti nel tronco encefalico, protesi dell’orecchio interno, neurostimolatori, codificatori della retina, pompe impiantate per l’infusione di farmaci
Lavoratori portatori di dispositivi medici impiantabili passivi contenenti metallo	Protesi articolari, chiodi, piastre, viti, clip chirurgiche, clip per aneurisma, stent, protesi valvolari cardiache, anelli per annuloplastica, impianti contraccettivi metallici e tipi di dispositivi medici impiantabili attivi
Lavoratori portatori di dispositivi medici indossati sul corpo	Pompe esterne per infusione di ormoni
Lavoratrici in gravidanza	

NB: Per valutare se i lavoratori sono particolarmente a rischio, i datori di lavoro dovranno prendere in considerazione la frequenza, il livello e la durata dell’esposizione.

Effetti avversi che possono essere indotti dalla esposizione (occupazionale) a CEM

Effetti biofisici diretti

1) ***effetti termici***
2) ***effetti non termici*** ***(****stimolazione di muscoli, nervi e organi sensoriali****)***
3) ***correnti negli arti***

Effetti indiretti

1) ***Interferenza:***
   a) ***dispositivi medici impiantati***
      - ***attivi***
      - ***passivi,***
   b) ***dispositivi medici portati sul corpo***
   c) ***dispositivi impiantati passivi / schegge, altri***
2) ***correnti di contatto***

Dispositivi medici impiantati di tipo passivo: effetti ipotizzabili

Effetto meccanico: *possibili dislocazioni del dispositivo in caso di presenza di componenti metalliche, per azione del campo statico*

Danno tissutale/del dispositivo: *possibile in caso di surriscaldamento del dispositivo per induzione di corrente o riscaldamento*

Dispositivi medici impiantati e indossabili di tipo attivo: effetti ipotizzabili

Errato sensing
(mancata stimolazione/stimolazione inappropriata)
Desettaggio
Effetto meccanico *(dislocazione)*
Risposta/danno tissutale *(correnti di contatto/aumento temperatura)*
Danneggiamento di componenti del dispositivo

Ha mai subito incidenti di caccia? SI NO

E' stato vittima di trauma da esplosione? SI NO

Piercing e tatuaggi?

Ha subito interventi chirurgici su : (barrare in caso negativo)

Testa ..... Addome .....

Collo ..... Estremità .....

Torace ..... Altri .....

E' portatore di:

- Schegge o frammenti metallici? SI NO
- Clips su aneurismi (vasi sanguigni), aorta, cervello? SI NO
- Protesi valvolare cardiaca? SI NO
- Loop recorder per il monitoraggio continuo ECG? SI NO
- Dispositivo di assistenza ventricolare (VAD)? SI NO
- Stabilizzatori / distrattori della colonna vertebrale? SI NO
- Pompa di infusione per insulina o altri farmaci? SI NO
- Pace-maker cardiaco o altri tipi di cateteri cardiaci? SI NO
- Corpi metallici nelle orecchie o impianti per l'udito? SI NO
- Protesi acustiche esterne? SI NO
- Neurostimolatori? SI NO
- Dispositivo intrauterino meccanico? SI NO
- Derivazione spinale o ventricolare per drenare il liquor? SI NO
- Protesi metalliche (per pregresse fratture, interventi correttivi articolari, etc.) viti, chiodi, filo, ecc.... SI NO

  Localizzazione .....
- Protesi dentarie fisse o mobili? SI NO

  Localizzazione .....
- Cristallino artificiale o altri impianti oculari? SI NO
- Protesi dell'arto superiore/mano? SI NO
- Protesi dell'arto inferiore/piede? SI NO
- Dispositivi indossabili ausiliatori/esoscheletri? SI NO

Possibile questionario anamnestico di screening per la presenza nei lavoratori di impianti attivi e non attivi e di inclusi metallici che potrebbero determinare problematiche da interferenza (CEI EN 50527-1, 2013, modificato).

European Heart Journal (2015) **36**, 1798–1804
doi:10.1093/eurheartj/ehv135

REVIEW

Novel Devices

Are patients with cardiac implants protected against electromagnetic interference in daily life and occupational environment?

Andreas Napp[1†*], Dominik Stunder[2†], Melanie Maytin[3], Thomas Kraus[2], Nikolaus Marx[1], and Sarah Driessen[2]

[1]Department of Internal Medicine I (Cardiology, Angiology, Pneumology and Internal Intensive Care Medicine), University Aachen 52074, Germany; [2]Research Center for Bioelectromagnetic Interaction, Institute of Occupational Medicine, Univer and [3]Division of Cardiovascular Medicine, Brigham and Women's Hospital, Boston, MA, USA

Received 6 December 2014; revised 14 March 2015; accepted 2 April 2015; online publish-ahead-of-print 23 April 2015

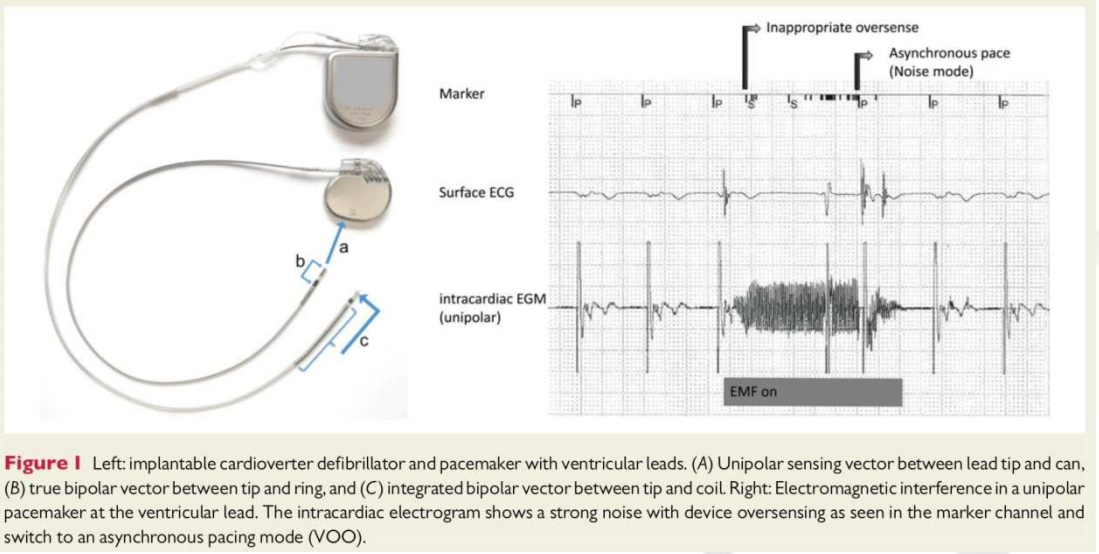


Figure 1 Left: implantable cardioverter defibrillator and pacemaker with ventricular leads. (*A*) Unipolar sensing vector between lead tip and can, (*B*) true bipolar vector between tip and ring, and (*C*) integrated bipolar vector between tip and coil. Right: Electromagnetic interference in a unipolar pacemaker at the ventricular lead. The intracardiac electrogram shows a strong noise with device oversensing as seen in the marker channel and switch to an asynchronous pacing mode (VOO).

- ***Probabilità di occorrenza usualmente bassa***
- ***Episodi spesso inosservati*** *(sottostima)*
- ***Alcuni dispositivi/configurazioni maggiormente a rischio***

Int Arch Occup Environ Health (2011) 84:1–6
DOI 10.1007/s00420-010-0599-y

ORIGINAL ARTICLE

Implantable cardioverter defibrillator and 50-Hz electric and magnetic fields exposure in the workplace

M. Souques · I. Magne · J. Lambrozo

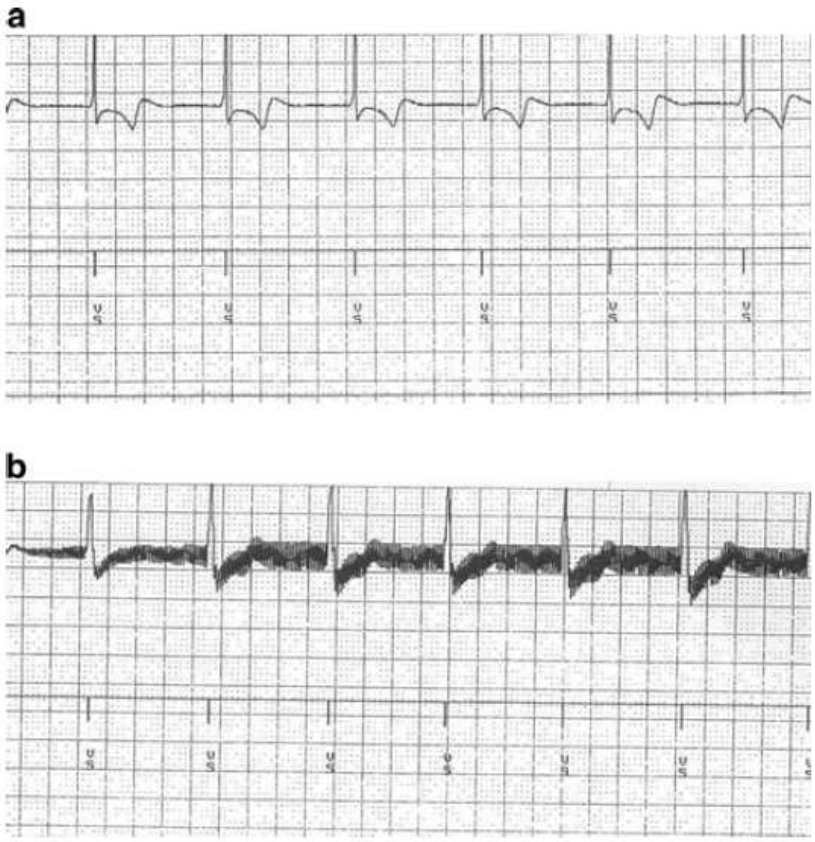


Fig. 1 **a** Measurement at maximal exposure (bipolar mode), **b** Measurement at maximal exposure (pseudo-unipolar mode)

Abstract

Purpose The operation of implantable cardioverter defibrillators (ICD) can be disrupted by exposure to electromagnetic fields (EMF). In the workplace, some workers can be exposed to EMF higher than in daily life. We present an approach aimed at assessing fitness for work in this type of situation, based on in situ case studies in the absence of clinical and in vivo studies.

Methods A risk assessment protocol was developed to measure the 50-Hz electric and magnetic fields in the various places where the worker is likely to be present. These measures are taken in the worker's presence, while monitoring the ICD operation.

Results All cases of implanted ICD workers in EDF, the French electricity company (around 130,000 employees), and potentially exposed to high electric and/or magnetic fields, between 2004 and 2009 are presented. These three cases involved different work circumstances, with exposure to 50-Hz electric and/or magnetic fields. No interference of the ICD was observed.

Conclusions This information provides the basis for the occupational physician to make a decision about fitness for work. This procedure can be extended to other medical implants and to electromagnetic fields frequencies other than 50-Hz.

Int Arch Occup Environ Health (2011) 84:1–6
DOI 10.1007/s00420-010-0599-y

ORIGINAL ARTICLE

Implantable cardioverter defibrillator and 50-Hz electric and magnetic fields exposure in the workplace

M. Souques · I. Magne · J. Lambrozo

Abstract

Purpose The operation of implantable cardioverter defibrillators (ICD) can be disrupted by exposure to electromagnetic fields (EMF). In the workplace, some workers can be exposed to EMF higher than in daily life. We present an approach aimed at assessing fitness for work in this type of on in situ case studies in the absence of o studies.

assessment protocol was developed to z electric and magnetic fields in the vari- the worker is likely to be present. These en in the worker's presence, while moni- eration.

s of implanted ICD workers in EDF, the company (around 130,000 employees), xposed to high electric and/or magnetic 004 and 2009 are presented. These three fferent work circumstances, with exposure and/or magnetic fields. No interference of the ICD was observed.

Conclusions This information provides the basis for the occupational physician to make a decision about fitness for work. This procedure can be extended to other medical implants and to electromagnetic fields frequencies other than 50-Hz.

Table 4 Procedures for defining fitness for work of workers with cardiac pacemakers and exposed to 50-Hz magnetic fields

Magnetic field (μT)	Cardiac pacemaker in unipolar mode	Cardiac pacemaker in bipolar mode
<45	Fit	Fit
≤100	Study of work station	Fit
>100	Study of work station	Study of work station

Europace (2013) **15**, 388–394
doi:10.1093/europace/eus345

CLINICAL RESEARCH
Pacing and resynchronization therapy

Electromagnetic interference with cardiac pacemakers and implantable cardioverter-defibrillators from low-frequency electromagnetic fields *in vivo*

Maria Tiikkaja[1]*, Aapo L. Aro[2], Tommi Alanko[1], Harri Lindholm[3], Heli Sistonen[3], Juha E.K. Hartikainen[4], Lauri Toivonen[2], Jukka Juutilainen[5], and Maila Hietanen[1]

[1]Safe New Technologies, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, 00250 Helsinki, Finland; [2]Department of Cardiology, Helsinki University Central Hospital, Haartmaninkatu 4, 00029 Helsinki, Finland; [3]Physical Work Capacity, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, 00250 Helsinki, Finland; [4]Heart Center, Kuopio University Hospital and University of Eastern Finland, PO Box 1777, 70211 Kuopio, Finland; and [5]Department of Environmental Science, University of Eastern Finland, PO Box 1627, 70211 Kuopio, Finland

Aims Electromagnetic interference (EMI) can pose a danger to workers with pacemakers and implantable cardioverter-defibrillators (ICDs). At some workplaces electromagnetic fields are high enough to potentially inflict EMI. The purpose of this *in vivo* study was to evaluate the susceptibility of pacemakers and ICDs to external electromagnetic fields.

Methods and results Eleven volunteers with a pacemaker and 13 with an ICD were exposed to sine, pulse, ramp, and square waveform magnetic fields with frequencies of 2–200 Hz using Helmholtz coil. The magnetic field flux densities varied to 300 μT. We also tested the occurrence of EMI from an electronic article surveillance (EAS) gate, an induction cooktop, and a metal inert gas (MIG) welding machine. All pacemakers were tested with bipolar settings and three of them also with unipolar sensing configurations. None of the bipolar pacemakers or ICDs tested experienced interference in any of the exposure situations. The three pacemakers with unipolar settings were affected by the highest fields of the Helmholtz coil, and one of them also by the EAS gate and the welding cable. The induction cooktop did not interfere with any of the unipolarly programmed pacemakers.

Conclusion Magnetic fields with intensities as high as those used in this study are rare even in industrial working environments. In most cases, employees can return to work after implantation of a bipolar pacemaker or an ICD, after an appropriate risk assessment. Pacemakers programmed to unipolar configurations can cause danger to their users in environments with high electromagnetic fields, and should be avoided, if possible.

Keywords Electromagnetic interference • Pacemaker • ICD • Low-frequency magnetic field • *in vivo* tests

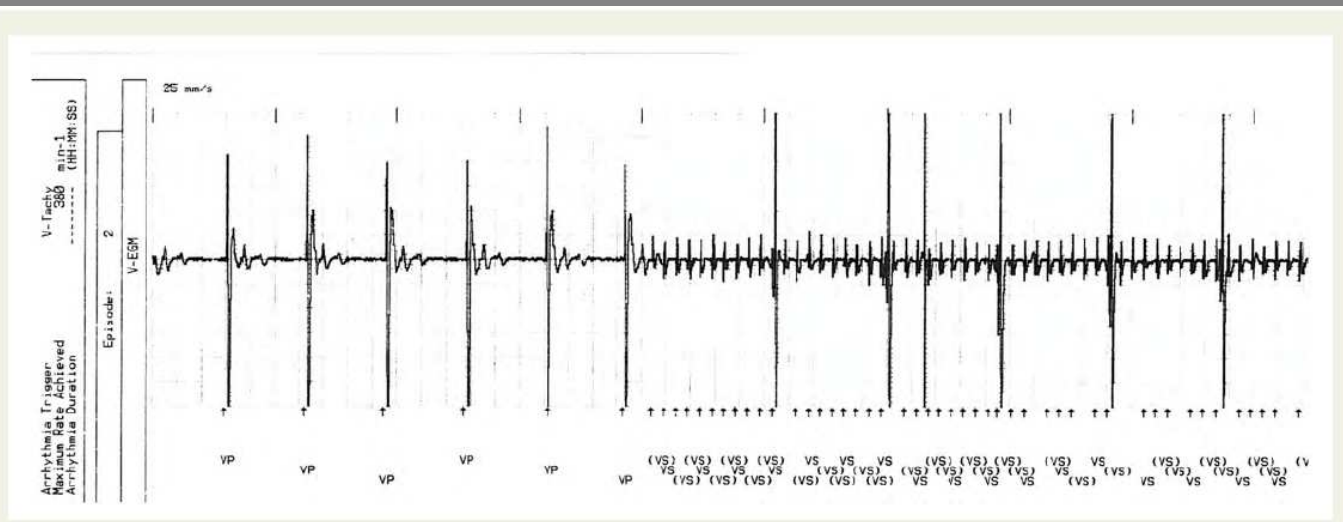


Figure 1 Inappropriate ventricular tachycardia detection and complete loss of pacing stored in electrogram due to inappropriate ventricular sensing during Exposure set-up III with Volunteer 5's unipolarly programmed pacemaker.

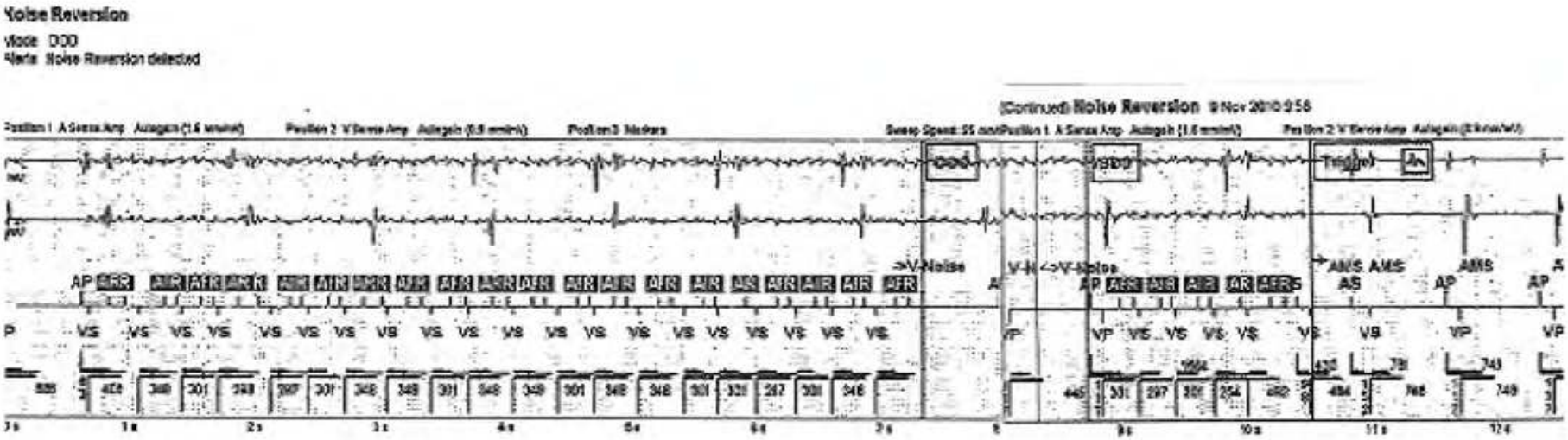


Figure 2 Stored electrogram showing inappropriate atrial and ventricular sensing episode resulting first in loss of pacing and then causing reversion to noise mode (DOO pacing) and an inappropriate auto mode switch episode during Exposure set-up III with Volunteer 8's pacemaker programmed to unipolar sensing settings.

Safety and Health at Work 4 (2013) 156–159

Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.org

Original Article

Testing of Common Electromagnetic Environments for Risk of Interference with Cardiac Pacemaker Function

Maria Tiikkaja [1,*], Aapo L. Aro [2], Tommi Alanko [1], Harri Lindholm [3], Heli Sistonen [3], Juha E.K. Hartikainen [4], Lauri Toivonen [2], Jukka Juutilainen [5], Maila Hietanen [1]

[1] *Safe New Technologies, Finnish Institute of Occupational Health, Helsinki, Finland*
[2] *Department of Cardiology, Helsinki University Central Hospital, Helsinki, Finland*
[3] *Physical Work Capacity, Finnish Institute of Occupational Health, Helsinki, Finland*
[4] *Heart Center, Kuopio University Hospital and School of Medicine, University of Eastern Finland, Kuopio, Finland*
[5] *Department of Environmental Science, University of Eastern Finland, Kuopio, Finland*

Background: Cardiac pacemakers are known to be susceptible to strong electromagnetic fields (EMFs). This *in vivo* study investigated occurrence of electromagnetic interference with pacemakers caused by common environmental sources of EMFs.

Methods: Eleven volunteers with a pacemaker were exposed to EMFs produced by two mobile phone base stations, an electrically powered commuter train, and an overhead high voltage transmission lines. All the pacemakers were programmed in normal clinically selected settings with bipolar sensing and pacing configurations.

Results: None of the pacemakers experienced interference in any of these exposure situations. However, often it is not clear whether or not strong EMFs exist in various work environments, and hence an individual risk assessment is needed.

Conclusions: Modern pacemakers are well shielded against external EMFs, and workers with a pacemaker can most often return to their previous work after having a pacemaker implanted. However, an appropriate risk assessment is still necessary after the implantation of a pacemaker, a change of its generator, or major modification of its programming settings.

Approccio alla valutazione della idoneità relativa a portatori di dispositivi medici impiantati attivi (DMIA)

- ***Definizione di tutte le sorgenti presenti***
- ***Valutazione del rischio*** *(norme tecniche)*
- ***Accertamento presenza di lavoratori con dispositivi impiantati/portati sul corpo***
- ***Necessità di valutazioni più approfondite*** *(approccio non clinico/clinico)*

Int Arch Occup Environ Health (2011) 84:1–6
DOI 10.1007/s00420-010-0599-y

ORIGINAL ARTICLE

Implantable cardioverter defibrillator and 50-Hz electric and magnetic fields exposure in the workplace

M. Souques · I. Magne · J. Lambrozo

Abstract

Purpose The operation of implantable cardioverter defibrillators (ICD) can be disrupted by exposure to electromagnetic fields (EMF). In the workplace, some workers can be exposed to EMF higher than in daily life. We present an approach aimed at assessing fitness for work in this type of on in situ case studies in the absence of o studies.

assessment protocol was developed to z electric and magnetic fields in the vari- the worker is likely to be present. These en in the worker's presence, while moni- eration.

s of implanted ICD workers in EDF, the company (around 130,000 employees), xposed to high electric and/or magnetic 004 and 2009 are presented. These three fferent work circumstances, with exposure and/or magnetic fields. No interference of the ICD was observed.

Conclusions This information provides the basis for the occupational physician to make a decision about fitness for work. This procedure can be extended to other medical implants and to electromagnetic fields frequencies other than 50-Hz.

Table 4 Procedures for defining fitness for work of workers with cardiac pacemakers and exposed to 50-Hz magnetic fields

Magnetic field (μT)	Cardiac pacemaker in unipolar mode	Cardiac pacemaker in bipolar mode
<45	Fit	Fit
≤100	Study of work station	Fit
>100	Study of work station	Study of work station

International Journal of Occupational Medicine and Environmental Health 2012;25(1):97–102
DOI 10.2478/s13382-012-0005-y

MENOMETRORRHAGIA IN MAGNETIC RESONANCE IMAGING OPERATORS WITH COPPER INTRAUTERINE CONTRACEPTIVE DEVICES (IUDS): A CASE REPORT

FABRIZIOMARIA GOBBA[1], NADIA BIANCHI[2], PAOLO VERGA[3], GIAN MARCO CONTESSA[4], and PAOLO ROSSI[4]

[1] University of Modena and Reggio Emilia, Modena, Italy
Department of Public Health Sciences
[2] Regional Health Service, Varese, Italy
Radioprotection Unit
[3] S. Carlo Borromeo Hospital, Milano, Italy
[4] Italian Worker's Compensation Authority (INAIL), Rome, Italy

Abstract

The paper describes the cases of 3 female health operators with implanted copper IUDs, developing menometrorrhagia some months after an increase of the working time in a Magnetic Resonance Imaging (MRI) Unit (1.5 T), that progressively disappeared when the previous organization, involving discontinuous work shifts at MRI, was re-established. No known factors possibly related to menometrorrhagia were evidenced in the 3 operators, supporting the hypothesis of a role of the exposure to the electromagnetic fields (EMF) induced by the MRI system in symptoms induction. The possible mechanism remains unsettled, but menometrorrhagia might be triggered by a phlogistic stimulus caused by EMF, possibly the low-frequency currents induced in the wires of the IUD during the movements of the operator inside the static magnetic field generated by the MRI permanent magnet. Until now, the problem of possible interactions between copper IUDs and EMF induced by MRI has been considered in patients undergoing imaging, but the possible risk in MRI Units operators has been largely neglected. To our knowledge, the occurrence of menometrorrhagia is not routinely checked in health surveillance of MRI operators, so these symptoms can pass unnoticed, especially if they are transitory. Therefore, underreporting is rather possible. The cases described here support the need for further research on this topic, especially considering the progressive diffusion of more powerful MRI scanners (3 T and more), and of the interventional magnetic resonance imaging, both potentially involving higher EMF exposures, and a large number of MRI female operators, possibly using IUDs. The possibility that MRI operators with implanted metallic IUDs can be included in the group of "workers at particular risk" according to the EU Directive 2004/40/EC should be considered.

BIOPHYSICS AND BASIC BIOMEDICAL RESEARCH - Full Papers

Magnetic Resonance in Medicine 79:1083–1089 (2018)

A Survey on Abnormal Uterine Bleeding among Radiographers With Frequent MRI Exposure Using Intrauterine Contraceptive Devices

A. Huss,* K. Schaap, and H. Kromhout

Purpose: Based on a previous case report of menometrorrhagia (prolonged/excessive uterine bleeding, occurring at irregular and/or frequent intervals) in MRI workers with intrauterine devices (IUDs), it was evaluated whether this association could be confirmed.

Methods: A survey was performed among 381 female radiographers registered with their national association. Logistic regression was used to analyze associations of abnormal uterine bleeding with the frequency of working with MRI scanners, presence near the scanner/in the scanner room during image acquisition, and with scanner strength or type.

Results: A total of 68 women reported using IUDs, and 72 reported abnormal uterine bleeding. Compared with unexposed women not using IUDs, the odds ratio in women with IUDs working with MRI scanners was 2.09 (95% confidence interval 0.83–3.66). Associations were stronger if women working with MRI reported being present during image acquisition (odds ratio 3.43, 95% CI 1.26–9.34). Associations with scanner strength or type were not consistent.

Conclusions: Radiographers using IUDs who are occupationally exposed to stray fields from MRI scanners report abnormal uterine bleeding more often than their co-workers without an IUD, or nonexposed co-workers with an IUD. In particular, radiographers present inside the scanner room during image acquisition showed an increased risk. **Magn Reson Med 79:1083–1089, 2018.** **© 2017 International Society for Magnetic Resonance in Medicine.**

Table 4
Association among Working with MRI Scanners, Being Present during Image Acquisition, and Abnormal Uterine Bleeding in Women Using IUDs

	N_t	N_c	OR (95% CI)	OR (95% CI)[a]	P[b]
Unexposed	29	4	Referent	Referent	
Working with MRI scanners	39	13	3.13 (0.90–10.88)	5.35 (1.13–25.37)	0.04
Unexposed	29	4	Referent	Referent	
Working with MRI scanners but never present during image acquisition	17	3	1.34 (0.26–6.86)	2.01 (0.29–13.72)	0.48
Working with MRI scanners and present during image acquisition	22	10	5.21 (1.35–20.06)	9.35 (1.72–50.94)	0.01

[a]Adjusted for age and age squared, work stress, emotional stress, and physical strain at work.
[b]*P* value from Wald tests in adjusted models.
N_t, total number of persons in category; N_c, number of cases with abnormal uterine bleeding in category.



Condizioni fisiologiche/patologiche che comportano una "particolare sensibilità" al rischio: lavoratrici in stato di gravidanza

La donna in gravidanza e il prodotto del concepimento: considerati potenzialmente particolarmente vulnerabili nei confronti degli effetti avversi di numerosi fattori di rischio di natura fisica, chimica e biologica.



Condizioni fisiologiche/patologiche che comportano una "particolare sensibilità" al rischio: lavoratrici in stato di gravidanza

D.Lgs. 81/2008 (come la Direttiva 2013/35/EU) include la gravidanza tra le condizioni di "particolare sensibilità al rschio da CEM, ma non fornisce VLE o VA specifici per le lavoratrici in stato di gravidanza

Environment International 112 (2018) 165–173

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Maternal cumulative exposure to extremely low frequency electromagnetic fields and pregnancy outcomes in the Elfe cohort

L. Migault[a,*], C. Piel[a], C. Carles[a,b], F. Delva[a], A. Lacourt[a], E. Cardis[c,d,e], C. Zaros[f], R. de Seze[g], I. Baldi[a,b], G. Bouvier[a]

[a] University of Bordeaux, Inserm U1219 EPICENE Team, Bordeaux Population Health Research Center, 146 rue Leo Saignat, 33076 Bordeaux Cedex, France
[b] Bordeaux University Hospital, Service de Médecine du Travail et pathologie professionnelle, 608 avenue Léon Duguit, 33600 Pessac, France
[c] Barcelona Institute for Global Health (ISGlobal), Doctor Aiguader, 88, 08003 Barcelona, Spain
[d] Universitat Pompeu Fabra Barcelona, Spain
[e] CIBER Epidemiologia y Salud Pública (CIBERESP), Madrid, Spain
[f] Joint research unit Elfe, Ined-Inserm-EFS, 133 Boulevard Davout, 75020 Paris, France
[g] TOXI PERITOX UMR-I-01 unit, INERIS, Parc ALATA BP2, 60550 Verneuil en Halatte, UPJV, Amiens, France

ARTICLE INFO

Editor: Yong Guan Zhu

Keywords:
Extremely low frequency electromagnetic fields
Maternal exposure
Occupational exposure
Small for gestational age
Prematurity

ABSTRACT

Objectives: To study the relations between maternal cumulative exposure to extremely low frequency electromagnetic fields (ELF EMF) and the risk of moderate prematurity and small for gestational age within the Elfe cohort.

Methods: The Elfe study included 18,329 infants born at 33 weeks of gestation or more in France in 2011 and was designed to follow the children until 20 years of age. Gestational age and anthropometric data at birth were collected in medical records and small for gestational age was defined according to a French customized growth standard. During interviews, mothers were asked to report their job status during pregnancy. If employed, their occupation was coded according to the International Standard Classification of Occupations 1988 and the date on which they stopped their work was recorded. Cumulative exposure to ELF EMF during pregnancy was assessed, for both mothers who worked and those who did not during pregnancy, using a recently-updated job-exposure matrix (JEM). Cumulative exposure was considered as a categorical variable (< 17.5, 17.5–23.8, 23.8–36.2, 36.2–61.6 or ≥ 61.6 μT-days), a binary variable (< 44.1 and ≥ 44.1 μT-days) and a continuous variable. Associations were analyzed by logistic regression, adjusting for the mother's lifestyle factors, socio-demographic characteristics and some mother's medical history during and before pregnancy. Analyses were restricted to single births and to complete values for the pregnancy outcomes (n = 16,733).

Results: Cumulative exposure was obtained for 96.0% of the mothers. Among them, 37.5% were classified in the 23.8–36.2 μT-days category, but high exposures were rare: 1.3% in the ≥ 61.6 μT-days category and 5.5% in the ≥ 44.1 μT-days category. No significant association was observed between maternal cumulative exposure and moderate prematurity and small for gestational age in this exposure range.

Conclusion: This large population-based study does not suggest that maternal exposure to ELF EMF during pregnancy is highly associated with risks of moderate prematurity or small for gestational age.

INTERNATIONAL JOURNAL OF RADIATION BIOLOGY
2018, VOL. 94, NO. 10, 902–908
https://doi.org/10.1080/09553002.2018.1439197

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Check for updates

A pilot study on the reproductive risks of maternal exposure to magnetic fields from electronic article surveillance systems

Muhammad Waseem Khan[a], Päivi Roivainen[a], Mikko Herrala[a], Maria Tiikkaja[b], Markku Sallmén[b], Maila Hietanen[b] and Jukka Juutilainen[a]

[a]Department of Environmental and Biological Sciences, University of Eastern Finland, Kuopio, Finland; [b]Research and Service Centre of Occupational Safety, Finnish Institute of Occupational Health, Helsinki, Finland

ABSTRACT

Purpose: We investigated the feasibility of a large-scale epidemiological study on reproductive effects of intermediate frequency (IF) magnetic field (MF) exposure among cashiers working near electronic article surveillance (EAS) systems.

Materials and methods: The study cohort included 4157 women who had worked as cashiers in supermarkets with EAS devices (considered as exposed) or grocery stores without EAS devices (considered as unexposed) between 2008 and 2015. 536 births and 38 miscarriages occurred among these women during the study period, based on information from nationwide health registries. Measurements were also performed to characterize the MF exposure of cashiers.

Results: Cashiers were found to be exposed to 8.2 MHz MFs only when passing by the gates at short distance. Static fields of about 0.1 mT were observed at cashier's seat. Extremely low frequency MFs were higher at stores without EAS devices. No differences on the risk of miscarriage, reduced birth weight or preterm birth were observed between cashiers in different store types.

Conclusions: Any further studies should attempt to include study subjects working near EAS systems that produce stronger IF MFs at kHz frequencies. Exposure to ELF MFs should be assessed as a possible confounding factor.

ARTICLE HISTORY
Received 14 December 2017
Revised 16 January 2018
Accepted 4 February 2018

KEYWORDS
Intermediate frequency magnetic fields; electronic article surveillance; maternal exposure; miscarriage; birth weight; gestational age

Ren et al. Environmental Health (2019) 18:6
https://doi.org/10.1186/s12940-019-0447-9

Environmental Health

RESEARCH Open Access

Prenatal exposure to extremely low frequency magnetic field and its impact on fetal growth

Yanfeng Ren[1†], Jianping Chen[2,3†], Maohua Miao[2], De-Kun Li[4], Hong Liang[2], Ziliang Wang[2], Fen Yang[2], Xiaowei Sun[2] and Wei Yuan[2*]

Abstract

Objective: Studies on the effect of prenatal exposure to magnetic field (MF) on fetal growth is inconclusive and subject to some methodological limitations, particularly in measurement of MF exposure. The present study aimed to examine the association between maternal extremely low frequency MF (ELF-MF) exposure during pregnancy and fetal growth in offspring.

Methods: A total of 128 pregnant women were recruited at their 3rd trimester and asked to wear an EMDEX Lite meter for 24 h to capture daily ELF-MF exposure. Time-weighted average (TWA), P50, and P75 of personal 24-h measurements were used to evaluate prenatal ELF-MF exposure. The medians of these measurements were used as cut-off points of high and low prenatal ELF-MF exposure. Fetal growth was measured by infant's birth weight, skinfold thickness of triceps, abdomen, and back, and circumference of head, upper arm, and abdomen. These measures were conducted within 24-h after birth. Generalized Linear Model was used to examine the association between maternal ELF-MF level and fetal growth indices after potential confounders were adjusted for.

Results: Compared with girls with lower prenatal ELF-MF exposure, girls with higher exposure had a lower birth weight, thinner skinfold of triceps, abdomen and back, and smaller circumference of head, upper arm and abdomen in all three ELF-MF matrices. The differences were statistically significant for birth weight and most other growth measurements ($P < 0.05$). These measures had no significant difference between higher and lower prenatal ELF-MF exposure in boys except back skinfold thickness.

Conclusion: Prenatal exposure to higher ELF-MF levels was associated with decreased fetal growth in girls, but not in boys.

Keywords: Magnetic field, Fetal growth, Cohort study, Pregnancy

American Journal of Epidemiology
© The Author(s) 2019. Published by Oxford University Press on behalf of the Johns Hopkins Bloomberg School of Public Health. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journalpermissions@oup.com.
Vol. 188, No. 7
DOI: 10.1093/aje/kwz092
Advance Access publication:
April 17, 2019

Original Contribution

Associations of Maternal Cell-Phone Use During Pregnancy With Pregnancy Duration and Fetal Growth in 4 Birth Cohorts

Ermioni Tsarna, Marije Reedijk, Laura Ellen Birks, Mònica Guxens, Ferran Ballester, Mina Ha, Ana Jiménez-Zabala, Leeka Kheifets, Aitana Lertxundi, Hyung-Ryul Lim, Jorn Olsen, Llúcia González Safont, Madhuri Sudan, Elisabeth Cardis, Martine Vrijheid, Tanja Vrijkotte, Anke Huss*, and Roel Vermeulen

* Correspondence to Dr. Anke Huss, Institute for Risk Assessment Sciences, Utrecht University, Yalelaan 2, NL-3508 TD Utrecht, the Netherlands (e-mail: A.Huss@uu.nl).

Results from studies evaluating potential effects of prenatal exposure to radio-frequency electromagnetic fields from cell phones on birth outcomes have been inconsistent. Using data on 55,507 pregnant women and their children from Denmark (1996–2002), the Netherlands (2003–2004), Spain (2003–2008), and South Korea (2006–2011), we explored whether maternal cell-phone use was associated with pregnancy duration and fetal growth. On the basis of self-reported number of cell-phone calls per day, exposure was grouped as none, low (referent), intermediate, or high. We examined pregnancy duration (gestational age at birth, preterm/postterm birth), fetal growth (birth weight ratio, small/large size for gestational age), and birth weight variables (birth weight, low/high birth weight) and meta-analyzed cohort-specific estimates. The intermediate exposure group had a higher risk of giving birth at a lower gestational age (hazard ratio = 1.04, 95% confidence interval: 1.01, 1.07), and exposure-response relationships were found for shorter pregnancy duration ($P < 0.001$) and preterm birth ($P = 0.003$). We observed no association with fetal growth or birth weight. Maternal cell-phone use during pregnancy may be associated with shorter pregnancy duration and increased risk of preterm birth, but these results should be interpreted with caution, since they may reflect stress during pregnancy or other residual confounding rather than a direct effect of cell-phone exposure.

Pre-term birth risk (OR)

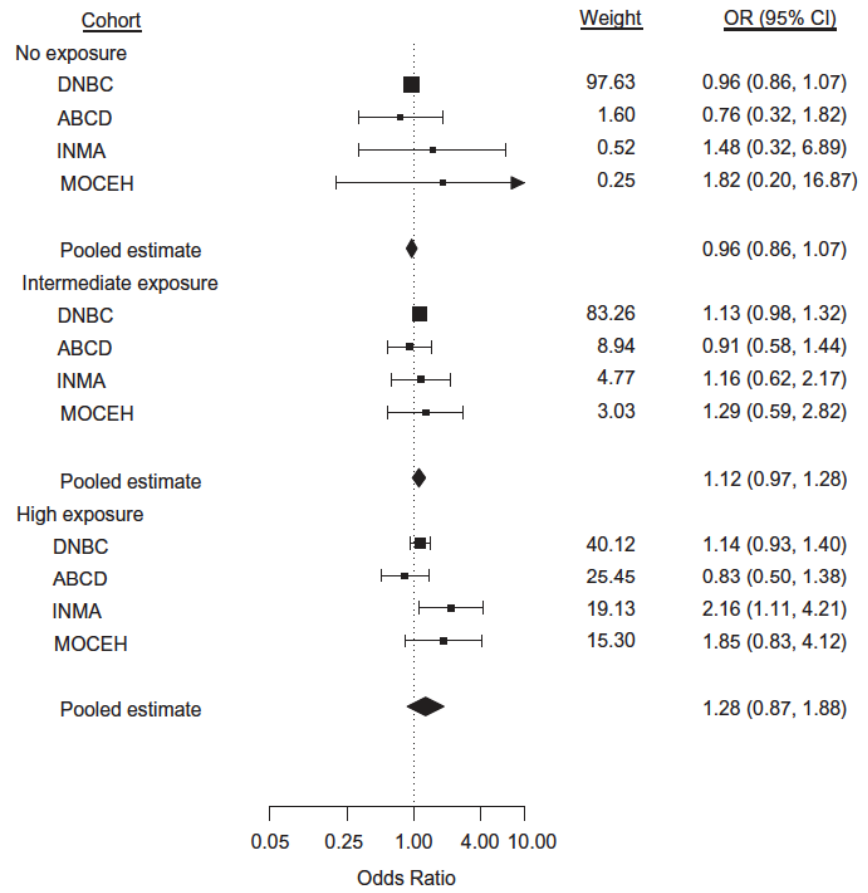


Figure 1. Odds ratios (ORs) from a meta-analysis of the association of maternal cell-phone use during pregnancy with the odds of giving birth preterm. The meta-analysis included data on 55,507 pregnant women and their children from Denmark (1996–2002), the Netherlands (2003–2004), Spain (2003–2008), and South Korea (2006–2011). In the DNBC, ABCD, and INMA cohorts, no exposure corresponded to no cell-phone use, low exposure to ≤1 call/day, intermediate exposure to 2–3 calls/day, and high exposure to ≥4 calls/day. In the MOCEH cohort, no exposure corresponded to no cell-phone use, low exposure to ≤2 calls/day, intermediate exposure to 3–5 calls/day, and high exposure to ≥6 calls/day. Low exposure was the referent group for all cohorts. Squares show individual study estimates; diamonds show pooled estimates. Results were adjusted for maternal age, parity, active and passive smoking, alcohol consumption, prepregnancy body mass index (weight (kg)/height $(m)^2$), educational level, socioeconomic position, marital status, and maternal height. For no exposure, $Q = 0.90$ (3 degrees of freedom (df)), $P = 0.83$, and $I^2 = 0.0\%$; for intermediate exposure, $Q = 0.92$ (3 df), $P = 0.82$, and $I^2 = 0.0\%$; and for high exposure, $Q = 6.32$ (3 df), $P = 0.10$, and $I^2 = 58.2\%$. Bars, 95% confidence intervals (CIs). ABCD, Amsterdam Born Children and Their Development Study; DNBC, Danish National Birth Cohort; INMA, Spanish Environment and Childhood Project; MOCEH, Korean Mothers and Children's Environment Health Study.

American Journal of Epidemiology
©The Author(s) 2019. Published by Oxford University Press on behalf of the Johns Hopkins Bloomberg School of Public Health. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journalpermissions@oup.com.
Vol. 188, No. 7
DOI: 10.1093/aje/kwz092
Advance Access publication:
April 17, 2019

Original Contribution

Associations of Maternal Cell-Phone Use During Pregnancy With Pregnancy Duration and Fetal Growth in 4 Birth Cohorts

Ermioni Tsarna, Marije Reedijk, Laura Ellen Birks, Mònica Guxens, Ferran Ballester, Mina Ha, Ana Jiménez-Zabala, Leeka Kheifets, Aitana Lertxundi, Hyung-Ryul Lim, Jorn Olsen, Llúcia González Safont, Madhuri Sudan, Elisabeth Cardis, Martine Vrijheid, Tanja Vrijkotte, Anke Huss*, and Roel Vermeulen

* Correspondence to Dr. Anke Huss, Institute for Risk Assessment Sciences, Utrecht University, Yalelaan 2, NL-3508 TD Utrecht, the Netherlands (e-mail: A.Huss@uu.nl).

Results from studies evaluating potential effects of prenatal exposure to radio-frequency electromagnetic fields from cell phones on birth outcomes have been inconsistent. Using data on 55,507 pregnant women and their children from Denmark (1996–2002), the Netherlands (2003–2004), Spain (2003–2008), and South Korea (2006–2011), we explored whether maternal cell-phone use was associated with pregnancy duration and fetal growth. On the basis of self-reported number of cell-phone calls per day, exposure was grouped as none, low (referent), intermediate, or high. We examined pregnancy duration (gestational age at birth, preterm/postterm birth), fetal growth (birth weight ratio, small/large size for gestational age), and birth weight variables (birth weight, low/high birth weight) and meta-analyzed cohort-specific estimates. The intermediate exposure group had a higher risk of giving birth at a lower gestational age (hazard ratio = 1.04, 95% confidence interval: 1.01, 1.07), and exposure-response relationships were found for shorter pregnancy duration ($P < 0.001$) and preterm birth ($P = 0.003$). We observed no association with fetal growth or birth weight. Maternal cell-phone use during pregnancy may be associated with shorter pregnancy duration and increased risk of preterm birth, but these results should be interpreted with caution, since they may reflect stress during pregnancy or other residual confounding rather than a direct effect of cell-phone exposure.

Temperature Increase in the Fetus Exposed to UHF RFID Readers

Serena Fiocchi*, Marta Parazzini, Ilaria Liorni, Theodoros Samaras, and Paolo Ravazzani

***Abstract*—Exposure to electromagnetic fields (EMFs) has prominently increased during the last decades due to the rapid development of new technologies. Among the various devices emitting EMFs, those based on Radio-frequency identification (RFID) technologies are used in all aspects of everyday life, and expose people unselectively. This scenario could pose a potential risk for some groups of the general population, such as pregnant women, who are expected to be possibly more sensitive to the thermal effects produced by EMF exposure. This is the first paper that addresses the estimation of temperature rise in two pregnant women models exposed to ultrahigh frequency RFID by computational techniques. Results show that the maximum temperature increase of the fetus and of the pregnancy-related tissues is relatively high (even about 0.7 °C), not too far from the known threshold of biological effects. However, this increase is confined to a small volume in the tissues.**

Per la tutela particolare della lavoratrice in gravidanza **il rispetto dei VLE previsti dal D.lgs. 81/08 può non essere sufficiente protettivo**

Opportuno cautelativamente fare riferimento a limiti più bassi:

- quelli per la popolazione **(Raccomandazione Europea 1999/519/CE)**
- valori limite **ICNIRP 2009** (campo magnetico statico) **e 2010** (campi variabili nel tempo, effetti non termici), riferimento scientifico più aggiornato

Se necessario:

- **valutazione individuale del rischio espositivo** (tipologia, modalità, durata, **localizzazione della esposizione** al corpo in toto o parziale)
- eventuale definizione di **misure di prevenzione e protezione individuali**

Legislazione di riferimento

D.lgs. 26.03.2001 n. 151 e s.m.i. "Testo Unico delle disposizioni legislative in materia di tutela e sostegno della maternità e della paternità, a norma dell'art. 15 della legge 8 marzo 2000"

prevede divieto di adibizione ad alcune lavorazioni ed esposizioni, mentre per alcuni fattori di rischio, comprese le radiazioni non ionizzanti, è prevista una valutazione particolarmente approfondita che tenga conto dello stato di maggior sensibilità della gestante (allegato C del D.lgs. 151/01), con individuazione di mansioni non pregiudizievoli per la salute della donna e del nascituro, modificando se possibile condizioni e orario di lavoro.

Condizioni fisiologiche/patologiche che comportano una "particolare sensibilità" al rischio da CEM:

***Oltre ai portatori di dispositivi medici impiantati, attivi o passivi, o dispositivi medici portati sul corpo e le lavoratrici in stato di gravidanza*, quali sono?**

"*Guida non vincolante di buone prassi*"

E.2.5 Lavoratori non specificati particolarmente a rischio

I datori di lavoro devono essere consapevoli che potrebbero esserci gruppi di lavoratori non specificati particolarmente a rischio, come lavoratori che assumono farmaci particolari per note patologie mediche.

Particolare sensibilità riconducibile a condizioni in grado di modificare le soglie di comparsa degli effetti avversi che possono essere indotti dalla esposizione (occupazionale) a CEM

Effetti biofisici diretti

Effetti termici (alte frequenze):

condizioni in grado di ridurre la soglia di tolleranza al riscaldamento di organi e tessuti (*NB: ma il rispetto del valori limite dovrebbe essere sufficiente per prevenirlo)*

Effetti non termici (basse frequenze):

condizioni in grado di ridurre la soglia di stimolazione di strutture nervose e della funzione sensoriale, attività EEG, funzione cardiaca.

Vertigine, instabilità:

Condizioni patologiche (S. di Mèniere, vertigine parossistica posizionale benigna, numerose altre), vari farmaci e sostanze ototossiche)

Fosfeni:

Condizioni patologiche (neuropatie ottiche, retinopatie) farmaci …..

Patologie del ritmo cardiaco

Occupational Magnetic Field Exposure and Myocardial Infarction Incidence

Anders Ahlbom,[*†] *Maria Feychting,*[*] *Annika Gustavsson,*[†] *Johan Hallqvist,*[†‡] *Christoffer Johansen,*[§] *Leeka Kheifets,*[‖] *and Jörgen H. Olsen*[§]

Background: Studies on healthy volunteers have seen reduced heart rate variability after exposure to extremely low-frequency electric and magnetic fields (EMF). Because reduced heart rate variability has been linked to cardiovascular disease risk, it has been hypothesized that exposure to EMF might increase the risk of cardiovascular disease. One epidemiologic study has shown increased mortality from cardiovascular conditions in utility workers with elevated exposure to magnetic fields, but several other epidemiologic studies have failed to confirm this result. We tested the hypothesis that occupational EMF exposure increases the risk of myocardial infarction in a large population-based case-control study of myocardial infarction, with detailed information on potential confounders.

Methods: We used data from the SHEEP study, which is a population-based case-control study of acute myocardial infarction in Stockholm. Occupational EMF exposure was based on job titles 1, 5, and 10 years before diagnosis. We used 2 approaches to classify exposure: first, specific individual job titles with presumed elevated EMF exposure, and second, classification of subjects according to a job-exposure matrix.

Results: We found no increased risk of myocardial infarction in subjects classified as having elevated EMF exposure. For the highest ≥0.3 μT according to the job-exposure matrix, isk was = 0.57 (95% confidence interval =

lts of this study do not support the hypothesis F exposure increases the risk of myocardial infarction.

Conclusions: The results of this study do not support the hypothesis that occupational EMF exposure increases the risk of myocardial infarction.

(*Epidemiology* 2004;15: 403–408)

Environmental Health

BioMed Central

Research

Open Access

Cardiovascular mortality and exposure to extremely low frequency magnetic fields: a cohort study of Swiss railway workers

Martin Röösli*[1], Matthias Egger[1,2], Dominik Pfluger[3] and Christoph Minder[1,4]

Address: [1]Institute of Social and Preventive Medicine (ISPM), University of Bern, Finkenhubelweg 11, 3012 Bern, Switzerland, [2]Department of Social Medicine, University of Bristol, Whiteladies Road, Bristol, BS8 2PR, UK, [3]datametrix AG, Zürich, Technoparkstrasse 1, 8005 Zürich, Switzerland and [4]Horten Zentrum, Medical Faculty, University of Zürich, 8091 Zürich, Switzerland

Email: Martin Röösli* - Roeoesli@ispm.unibe.ch; Matthias Egger - Egger@ispm.unibe.ch; Dominik Pfluger - dhp@solnet.ch; Christoph Minder - cminder@ispm.unibe.ch

* Corresponding author

Published: 1 July 2008

Environmental Health 2008, **7**:35 doi:10.1186/1476-069X-7-35

Abstract

Background: Exposure to intermittent magnetic fields of 16 Hz has been shown to reduce heart rate variability, and decreased heart rate variability predicts cardiovascular mortality. We examined mortality from cardiovascular causes in railway workers exposed to varying degrees to intermittent 16.7 Hz magnetic fields.

Methods: We studied a cohort of 20,141 Swiss railway employees between 1972 and 2002, including highly exposed train drivers (median lifetime exposure 120.5 μT-years), and less or little exposed shunting yard engineers (42.1 μT-years), train attendants (13.3 μT-years) and station masters (5.7 μT-years). During 464,129 person-years of follow up, 5,413 deaths were recorded and 3,594 deaths were attributed to cardio-vascular diseases. We analyzed data using Cox proportional hazards models.

Results: For all cardiovascular mortality the hazard ratio compared to station masters was 0.99 (95%CI: 0.91, 1.08) in train drivers, 1.13 (95%CI: 0.98, 1.30) in shunting yard engineers, and 1.09 (95%CI: 1.00, 1.19) in train attendants. Corresponding hazard ratios for arrhythmia related deaths were 1.04 (95%CI: 0.68, 1.59), 0.58 (95%CI: 0.24, 1.37) and 10 (95%CI: 0.87, 1.93) and for acute myocardial infarction 1.00 (95%CI: 0.73, 1.36), 1.56 (95%CI: 1.04, 2.32), and 1.14 (95%CI: 0.85, 1.53). The hazard ratio for arrhythmia related deaths per 100 μT-years of cumulative exposure was 0.94 (95%CI: 0.71, 1.24) and 0.91 (95%CI: 0.75, 1.11) for acute myocardial infarction.

Conclusion: This study provides evidence against an association between long-term occupational exposure to intermittent 16.7 Hz magnetic fields and cardiovascular mortality.

ORIGINAL ARTICLE

Occupational exposure to extremely low-frequency magnetic fields and cardiovascular disease mortality in a prospective cohort study

Tom Koeman,[1] Pauline Slottje,[1] Hans Kromhout,[1] Leo J Schouten,[2] R Alexandra Goldbohm,[3] Piet A van den Brandt,[2] Roel Vermeulen[1,4]

Koeman T, *et al. Occup Environ Med* 2013;**70**:402–407. doi:10.1136/oemed-2012-100889

ABSTRACT

Objectives Although a study among utility workers found an increased risk for acute myocardial infarction and arrhythmia-related deaths associated with occupational extremely low-frequency magnetic fields (ELF-MF) exposure, later studies largely failed to replicate these findings. This study investigated the association between occupational ELF-MF exposure and cardiovascular disease (CVD) mortality within a community-based prospective cohort study.

Methods The Netherlands Cohort Study is a prospective cohort study among 120 852 men and women aged 55–69 years at baseline. Participants were followed-up for CVD mortality over a period of 10 years, resulting in 8200 CVD deaths. Information on occupational history and potential confounders, such as educational level, smoking and alcohol use were collected at baseline through a self-administered questionnaire. Occupational ELF-MF exposure was assigned using a job-exposure matrix. Associations with CVD mortality were analysed using Cox regression.

Results Ever low or high exposure to ELF-MF showed no association with total CVD mortality (HR of 1.02, 95% CI 0.99 to 1.06), nor with any cause-specific subtypes of CVD mortality. Other ELF-MF exposure metrics showed no increased risks either.

Conclusions In this study, we found no indication of an association between occupational ELF-MF exposure and risk of CVD mortality.

Review

Scand J Work Environ Health 2007;33(1):5–12

Extremely low-frequency magnetic fields and heart disease

by Leeka Kheifets, PhD,[1] Anders Ahlbom, PhD,[2, 3] Christoffer Johansen, PhD,[4] Maria Feychting, PhD,[2, 5] Jack Sahl, PhD,[6] David Savitz, PhD[7]

Kheifets L, Ahlbom A, Johansen C, Feychting M, Sahl J, Savitz D. Extremely low-frequency magnetic fields and heart disease. *Scand J Work Environ Health* 2007;33(1):5–12.

The biologically based hypothesis that magnetic fields increase the risk of conditions related to cardiac arrhythmia and acute myocardial infarction but not chronic cardiovascular disease was initially supported by the results of an epidemiologic study. High rates of cardiovascular disease and relatively common exposure to magnetic fields made it an important public health question. Most of the epidemiologic studies that followed showed no effect. In this paper the basis for both this hypothesis and the epidemiologic studies that tested it are presented. It was concluded that the evidence speaks against an etiologic relation between exposure to electric and magnetic fields and cardiovascular disease. This effort represents an interesting case study of a scientific inquiry that has been successfully resolved despite numerous methodological difficulties inherent in research on low-level environmental exposures.

Int Arch Occup Environ Health (2009) 82:919–933
DOI 10.1007/s00420-009-0404-y

REVIEW

A literature review: the cardiovascular effects of exposure to extremely low frequency electromagnetic fields

David Andrew McNamee · Alexandre G. Legros · Daniel R. Krewski · Gerald Wisenberg · Frank S. Prato · Alex W. Thomas

Conclusions and future directions

While studies of the potential effects of EMF exposure on cardiovascular function conducted to date have provided some evidence of a possible association, the current weight of scientific evidence is largely inconclusive. Preece et al.

Bioelectromagnetics 39:277–288 (2018)

Heart Rate Variability Affected by Radiofrequency Electromagnetic Field in Adolescent Students

Jakub Misek,[1]* Igor Belyaev,[2,3] Viera Jakusova,[4] Ingrid Tonhajzerova,[5,6] Jan Barabas,[7] and Jan Jakus[1]

[1]*Jessenius Faculty of Medicine in Martin, Department of Medical Biophysics, Comenius University in Bratislava, Martin, Slovakia*
[2]*Laboratory of Radiobiology, Slovak Academy of Science, Biomedical Research Center, Cancer Research Institute, Bratislava, Slovakia*
[3]*Laboratory of Radiobiology, Russian Academy of Science, Prokhorov General Physics Institute, Moscow, Russia*
[4]*Jessenius Faculty of Medicine in Martin, Department of Public Health, Comenius University in Bratislava, Martin, Slovakia*
[5]*Jessenius Faculty of Medicine in Martin, Department of Physiology, Comenius University in Bratislava, Martin, Slovakia*
[6]*Jessenius Faculty of Medicine in Martin, Biomedical Center Martin, Comenius University in Bratislava, Martin, Slovakia*
[7]*University of Zilina, University Science Park, Zilina, Slovakia*

This study examines the possible effect of radiofrequency (RF) electromagnetic fields (EMF) on the autonomic nervous system (ANS). The effect of RF EMF on ANS activity was studied by measuring heart rate variability (HRV) during ortho-clinostatic test (i.e., transition from lying to standing and back) in 46 healthy grammar school students. A 1788 MHz pulsed wave with intensity of 54 ± 1.6 V/m was applied intermittently for 18 min in each trial. Maximum specific absorption rate (SAR_{10}) value was determined to 0.405 W/kg. We also measured the respiration rate and estimated a subjective perception of EMF exposure. RF exposure decreased heart rate of subjects in a lying position, while no such change was seen in standing students. After exposure while lying, a rise in high frequency band of HRV and root Mean Square of the Successive Differences was observed, which indicated an

the trial. In conclusion, short-term RF EMF exposure of students in a lying position during the ortho-clinostatic test affected ANS with significant increase in parasympathetic nerve activity compared to sham exposed group. Bioelectromagnetics. 39:277–288, 2018. © 2018 Wiley Periodicals, Inc.

European Health Risk Assessment Network on Electromagnetic Fields Exposure

Risk analysis of human exposure to electromagnetic fields

Deliverable Report D2 of EHFRAN project

Actual date of submission July 2010, last revision 2012

Draft prepared by Zenon Sienkiewicz, Joachim Schüz, Aslak Harbo Poulsen, Elizabeth Cardis

Health Programme 2008-2013 Together for Health

Executive Agency for Health and Consumers

Outcome	Strength of evidence
Cancer outcomes	
Leukaemia in children	Limited
Brain tumours in children	Inadequate
Brain tumours in adults	Inadequate
Breast cancer in adults	Lack of effect
Other cancer (children or adults)	Inadequate
Neurodegenerative diseases	
Alzheimer's disease	Inadequate
Amyotrophic lateral sclerosis (ALS)	Inadequate
Other neurodegenerative diseases	Inadequate
Reproductive outcomes	
All outcomes	Inadequate
Cardiovascular diseases	
All diseases	Lack of effect
Well-being	
Electrical hypersensitivity (EHS)	Lack of effect
Symptoms	Inadequate

Table 2. The strength of evidence for any health outcome being associated with exposure to low frequency magnetic fields as suggested by EMF-NET (2009) and SCENIHR (2009a) and modified by the results of more recent research.



Outcome	Strength of evidence
Cancer outcomes	
Leukaemia in children	Inadequate
Brain tumours in children	Inadequate
Brain tumours in adults	Limited
Breast cancer in adults	Inadequate
Other cancer (children or adults)	Inadequate
Neurodegenerative diseases	
Alzheimer's disease	Inadequate
Amyotrophic lateral sclerosis (ALS)	Inadequate
Other neurodegenerative diseases	Inadequate
Reproductive outcomes	
All outcomes	Inadequate
Cardiovascular diseases	
All diseases	Inadequate
Well-being	
Electrical hypersensitivity (EHS)	Lack of effect
Symptoms	Inadequate

Table 4. The strength of evidence for any health outcome being associated with exposure to RF fields as suggested by EMF-NET (2009) and SCENIHR (2009a) and modified by the results of more recent research.

EFHRAN 2012

CONCLUSIONI:

Criteri per la idoneità di lavoratori con condizioni fisiologiche/patologiche che comportano una “particolare sensibilità” al rischio da CEM

- **Soggetti portatori di dispositivi medici impiantati, attivi o passivi, altri impianti passivi, dispositivi medici portati sul corpo: approccio non clinico/clinico**
- **Lavoratrici in stato di gravidanza: limitazione esposizione (limiti 1999/519/CE, ICNIRP, valutazione individuale)**
- **Altre condizioni: i dati finora disponibili sono inadeguati per pervenire a delle conclusioni evidence based**