UNIVERSITÀ DEGLI STUDI DI PARMA

F. NONNIS MARZANO

Dipartimento di Biologia Evolutiva e Funzionale
Università di Parma

La Spezia, 27 Novembre 2010
Giornata Regionale SIDS, SIUD e ALTE

SIDS/SUID

(Sudden Infant Death Syndrome)

SIUD/MEF

(Sudden Intrauterine Unexplained Death)

ALTE

(Apparent Life Threatening Events)

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GENETICA FORENSE

GENETICS

Crib Death Exoneration Could Usher In New Gene Te

CAMBRIDGE, U.K.—For years, prosecutors in the United Kingdom have applied an unwritten three-strikes-and-you're-out rule to mothers whose babies die in infancy: One unexplained death is tragic but innocent, two is suspicious, and three is murder. This credo, tested in many a court case, led the U.K.'s Crown Prosecution Service to try a pharmacist named Trupti Patel for murder. Over a 4-year span, Patel and her husband, Jay, lost three babies before the age of 3 months. An open-and-shut case? Far from it. Recent genetic studies that challenge the three-strikes rule were a decisive factor in Patel's stunning acquittal last week in Reading Crown Court.

Vindicated. Jay and Trupti Patel were all smiles outside the courthouse last week after a jury cleared Trupti of wrongdoing. Recent genetic findings appear to have played a decisive role in the verdict.

The ruling could have profound implications for criminal justice. Well-publicized trials in which multiple cases of sudden infant death syndrome (SIDS) led to murder convictions have tended to discredit the idea that SIDS could run in families. In the wake of the Patel ruling, many lawyers and child protection advocates have criticized the eagerness to prosecute cases of multiple unexplained infant deaths. The outcome could lead to more extensive screening of babies for inherited disorders, as well as to genetic testing of mothers accused of killing their babies.

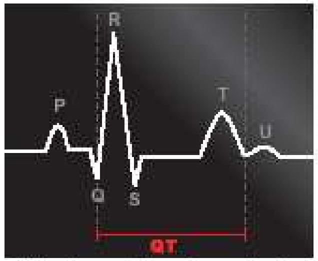
SIDS, sometimes called crib or cot death, is a "diagnosis of exclusion," notes the American Academy of Pediatrics. Doctors assign a death to SIDS only after an autopsy and examination of the baby's environment and medical history reveal no other possibilities. Although the cause or causes of SIDS are unclear, breathing difficulties appear to play a central role. In the last decade, a "Back to Sleep" campaign urging parents to avoid allowing babies to sleep on their stomachs appears to have had major benefits: Since 1991, the number of SIDS cases has fallen by 50% in the United States, although it is still the third leading cause of U.S. infant mortality.

Pathologists have testified that the odds of two or more siblings dying of SIDS are vanishingly small: When factors such as parental smoking or low birth weight, which increase the risk of SIDS, are excluded, coincidence cannot provide a plausible explanation for multiple SIDS deaths. Negligence or child abuse is a far more likely cause, prosecutors argue.

The underpinnings of the three-strikes rule rest largely on a 1977 study by retired U.K. pediatrician and child abuse expert Roy Meadow. He invoked a disorder called "Munchausen syndrome by proxy," in which caregivers in multiple SIDS cases inflict suffering to get attention or sympathy. Meadow has served as an expert witness in several successful prosecutions of multiple unexplained infant deaths, and he testified for the prosecution in the Patel case; he declined to comment for this article.

In the Patel case, the defense challenged the basis of the three-strikes rule, arguing that genetics, not coincidence, lies behind the tragic deaths. Suggestions of a genetic link came from Patel's grandmother, who told the jury that five of her own children died—including three before the age of 6 weeks of unexplained causes—in the 1940s in Gujarat, India. The prosecution did not offer evidence to the contrary.

But it was the scientific testimony that provided the real fireworks. M
clinical geneticist at St. Geo
London, testified that an auto
inheritance pattern with "vari
could explain the Patel famil
fant deaths. He suggested t
mitochondrial respiratory ch
set of conditions in which m
clear and mitochondrial DN
metabolism—and long QT s
arrhythmia known for striki
athletes and linked to mutat
transport genes. Patton estim
miss about 30% of long QT
identifiable by electrocardiog



Telltale electrocardiogram. A sometimes fatal heart arrhythmia called long QT syndrome may underlie some SIDS cases.

Doctors had tested Patel's
for problems with heart rhyth
10 days before her death and
malities. However, biochemic
the infants provided some su
tion of a mitochondrial disor
based defense was robust e
reasonable doubt in the mi
which cleared Patel after
barely 90 minutes.

Other findings not aired
could explain some SIDS cas
an inability to metabolize fa
masquerade as SIDS. And
linked to the IL-10 gene: Ba
ticular allele have an exagger
sponse to common infections
ogist David Drucker of th
Manchester, U.K. Inherite
combine synergistically, he s
such as parental smoking or s
to trigger harmful fluid build

The bottom line, says P
pediatrician at the Universit
testified in the Patel case, is t
should routinely take and r
DNA samples and screen fo
orders and heart arrythmias
rector of the National Cente
orders Research in Bethesda
an expert on SIDS diagnosis
are multiple genetic risk fa
just as for any other conditio

The Patel case has given
proposal last month from t
pendent Review of Corone
panels conduct inquiries int
they arise. In the United Sta
genetic explanations for mult
is "just beginning to cha
widely accepted," Hunt says
the explosion of genetic i
need to take a fresh look at S

Quinn Eastman has just comple
in the Cambridge, U.K., office of S

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Relazione di consulenza ostetrica e medico-legale nel procedimento penale n 5572/07.

- Procura della Repubblica presso il Tribunale di [redacted]
- Dr.ssa [redacted]
- Proc. n 5572/07.
- Incarico del 9 luglio 2008.

[redacted] 20 gennaio 2009

Dott. [redacted]

Dott. [redacted]

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The Sudden Infant Death Syndrome Gene: Does It Exist?

Siri H. Opdal, PhD, and Torleiv O. Rognum, MD

ABSTRACT. ***Background.*** Sudden infant death syndrome (SIDS) is in a difficult position between the legal and medical systems. In the United Kingdom, prosecutors have for years applied the simple rule that 1 unexpected death in a family is a tragedy, 2 are suspicious, and 3 are murder. However, it seems that the pendulum has now swung to the opposite extreme; mutations or polymorphisms with unclear biological significance are accepted in court as possible causes of death. This development makes research on genetic predisposing factors for SIDS increasingly important, from the standpoint of the legal protection of infants. The genetic component of sudden infant death can be divided into 2 categories, ie (1) mutations that give rise to genetic disorders that constitute the cause of death by themselves and (2) polymorphisms that might predispose infants to death in critical situations. Distinguishing between these 2 categories is essential, and cases in which a mutation causing a lethal genetic disorder is identified should be diagnosed not as SIDS but as explained death.

Genetic Alterations That May Cause Sudden Infant Death. Deficiencies in fatty acid metabolism have been extensively studied in cases of SIDS, and by far the most well-investigated mutation is the A985G mutation in the medium-chain acyl-CoA dehydrogenase (MCAD) gene, which is the most prevalent mutation causing MCAD deficiency. How
investigated ha
chemical profil
disorders in a r
portance of inv
other than MCA
may cause sudd
novel polymorphisms have been found when key proteins involved in the regulation of blood glucose levels are investigated in cases of SIDS. The long QT syndrome (LQTS) is another inherited condition proposed as the cause of death in some cases of sudden infant death. The LQTS is caused by mutations in genes encoding cardiac ion channels, and mutations in the genes ***KVLQT1*** and ***SCNA5*** have been identified in cases initially diagnosed as SIDS, in addition to several polymorphisms in these 2 genes and in the ***HERG*** gene. In addition, genetic risk factors for thrombosis were investigated in a small number of SIDS cases; the study concluded that venous thrombosis is not a major cause of sudden infant death.

Gene Polymorphisms That May Predispose Infants to Sudden Infant Death Under Certain Circumstances. Many SIDS victims have an activated immune system, which may indicate that they are vulnerable to simple infections. One reason for such vulnerability may be partial deletions of the complement component 4 gene. In cases of SIDS, an association between slight infections before death and partial deletions of the complement component 4 gene has been identified, which may indicate that this combination represents increased risk of sudden infant death. There have been a few studies investigating HLA-DR genotypes and SIDS, but no association has been demonstrated. The most common polymorphisms in the interleukin-10 (IL-10) gene promoter have been investigated in SIDS cases, and the ***ATA/ATA*** genotype has been reported to be associated with both SIDS and infectious death. The findings may indicate that, in a given situation, an infant with an unfavorable IL-10 genotype may exhibit aberrant IL-10 production, and they confirm the assumption that genes involved in the immune system are of importance with respect to sudden unexpected infant death. Another gene that has been investigated is the serotonin transporter gene, and an association between the long alleles of this gene and SIDS has been demonstrated. Serotonin influences a broad range of physiologic systems, as well as the interactions between the immune and nervous systems, and findings of decreased serotonergic binding in parts of the brainstem, together with the findings in the serotonin
ages between common polymorphisms in these genes and SIDS. A number of human diseases are attributable to mutations in mitochondrial DNA (mtDNA), and there are several reasons to think that mtDNA mutations also are involved in SIDS. Both a higher substitution frequency and a different substitution pattern in the ***HVR-I*** region of mtDNA have been reported in SIDS cases, compared with control cases. A number of coding region mtDNA mutations have also been reported, but many are found only in 1 or a few SIDS cases, and, to date, no predominant mtDNA mutation has been found to be associated with SIDS.

Conclusions. All mutations giving rise to metabolic disorders known to be associated with life-threatening events are possible candidates for genes involved in cases of sudden infant death, either as a cause of death or as a predisposing factor. It is necessary to distinguish between lethal mutations leading to diseases such as MCAD and LQTS, and polymorphisms (for instance, in the IL-10 gene and mtDNA) that are normal gene variants but might be suboptimal in critical situations and thus predispose infants to sudden infant death. It is unlikely that one mutation or polymorphism is the predisposing factor in all SIDS cases. However, it is likely that there are "SIDS genes" operating as a polygenic inheritance predisposing infants to sudden infant death, in combi-

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SIDS: Esiste un gene specifico?

Auckland, Nuova Zelanda (2000) | **1 lavoro**

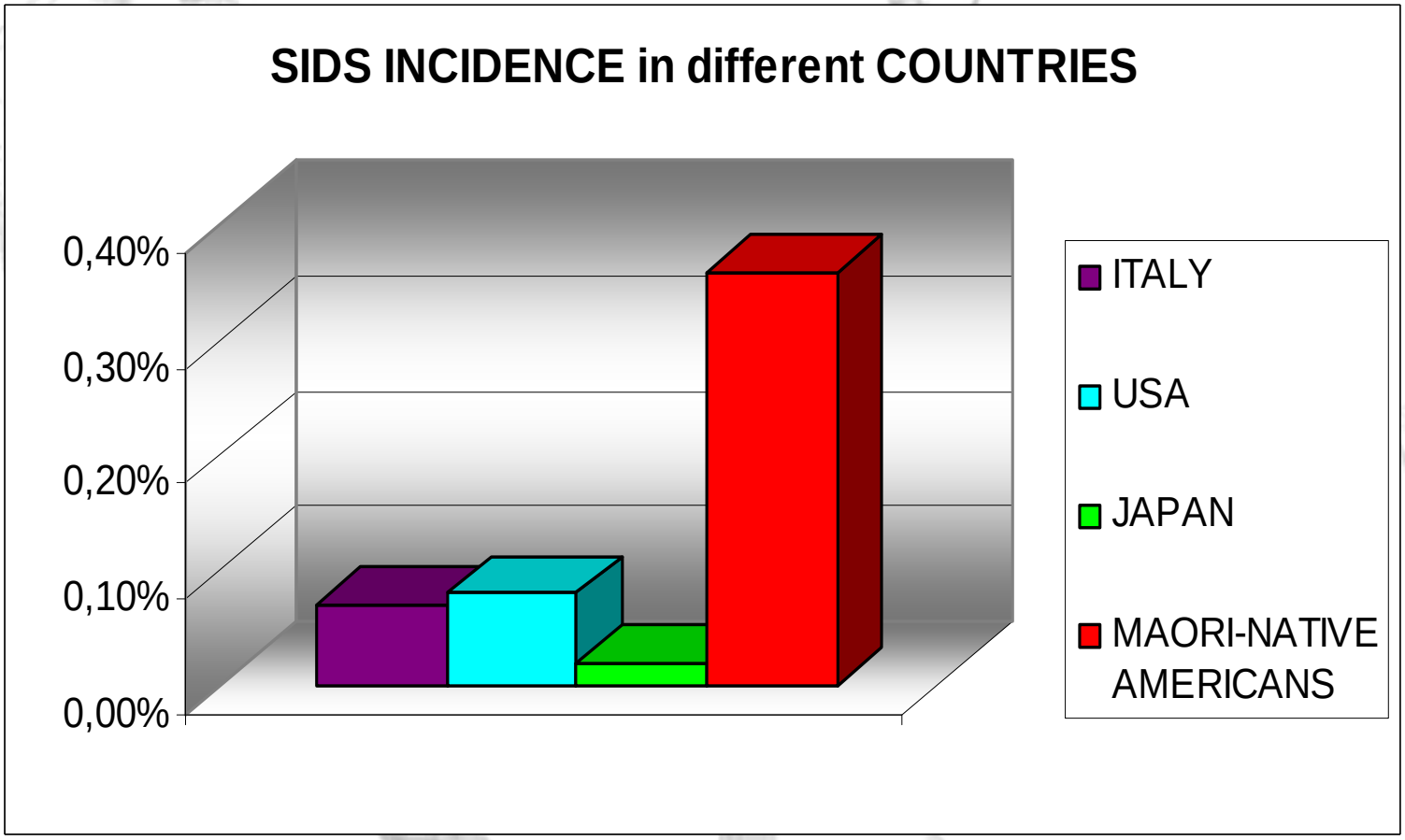
Firenze, Italia (2002) | **4 lavori**

Edmonton, Canada (2004) | **4 lavori**

Yokohama, Giappone (2006)
12 lavori

Portsmouth, UK (2008)
16 lavori

SIDS


SIDS INCIDENCE in different COUNTRIES
0,40%
0,30%
0,20%
0,10%
0,00%
ITALY
USA
JAPAN
MAORI-NATIVE AMERICANS

GENETICA e SIDS

Opdal e Rognum (2004); Hunt (2005)

1. MUTAZIONI

↓

MALATTIE GENETICHE

↓

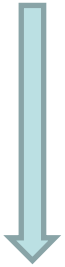
MORTE

2. POLIMORFISMI

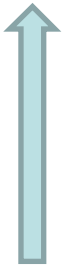
↓

PREDISPOSIZIONE - INTERAZIONE CON AMBIENTE

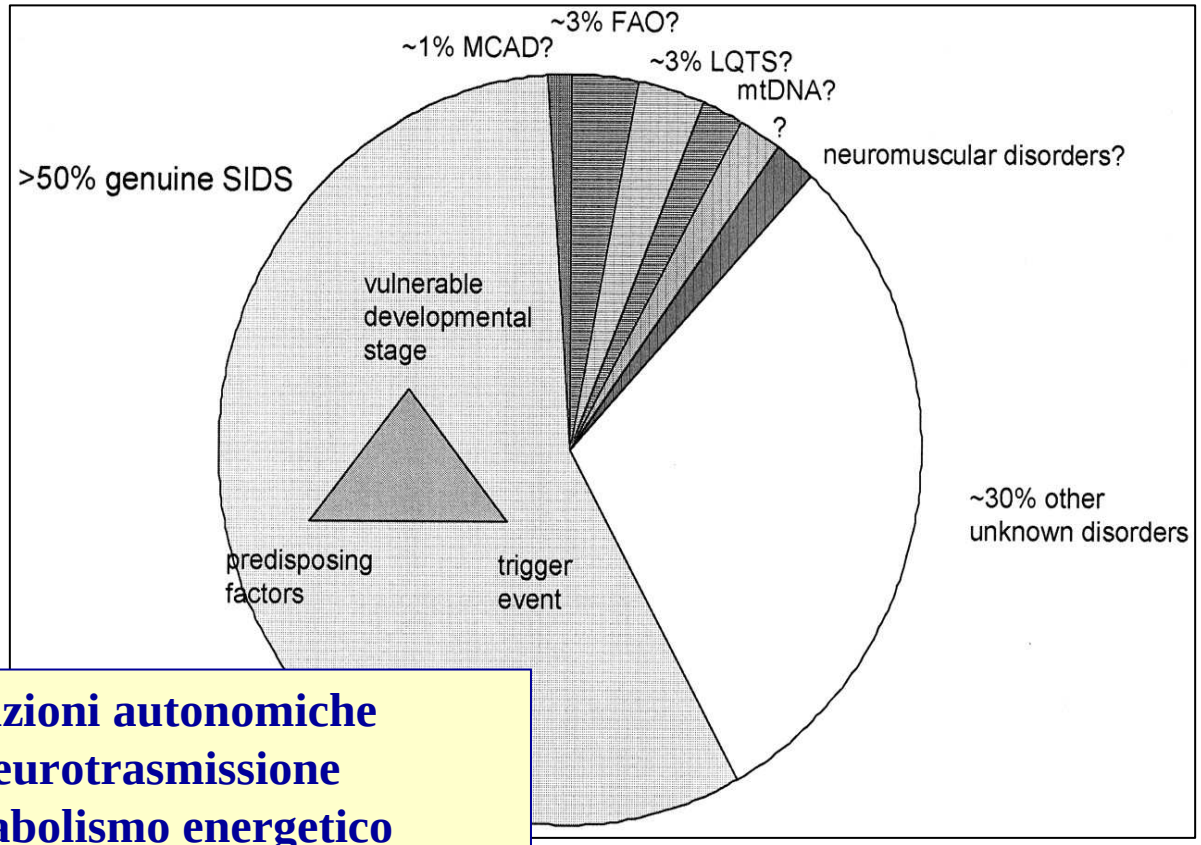
Componente biologica



GENETICS LOADS THE GUN
AND
THE ENVIRONMENT PULLS THE TRIGGER



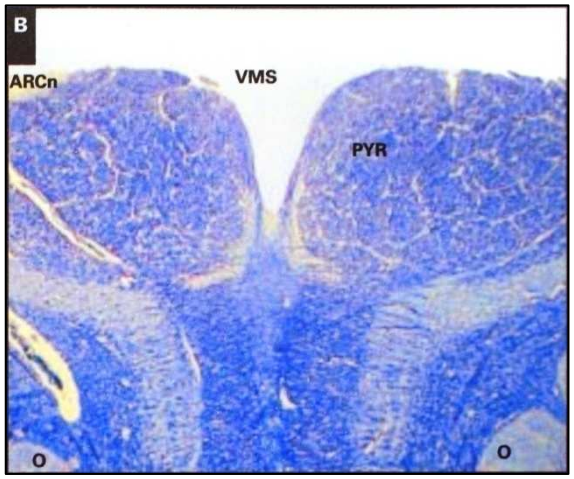
Componente ambientale



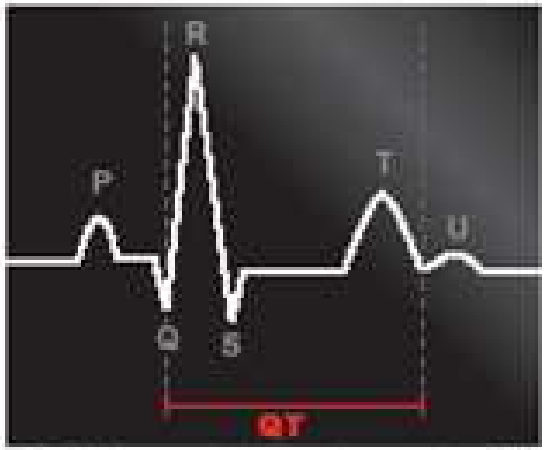
Funzioni autonomiche
Neurotrasmissione
Metabolismo energetico
Risposta immunitaria

PEDIATRICS®

Affinità patogenetica
BULBO-SPINALE (Matturri, 2005)

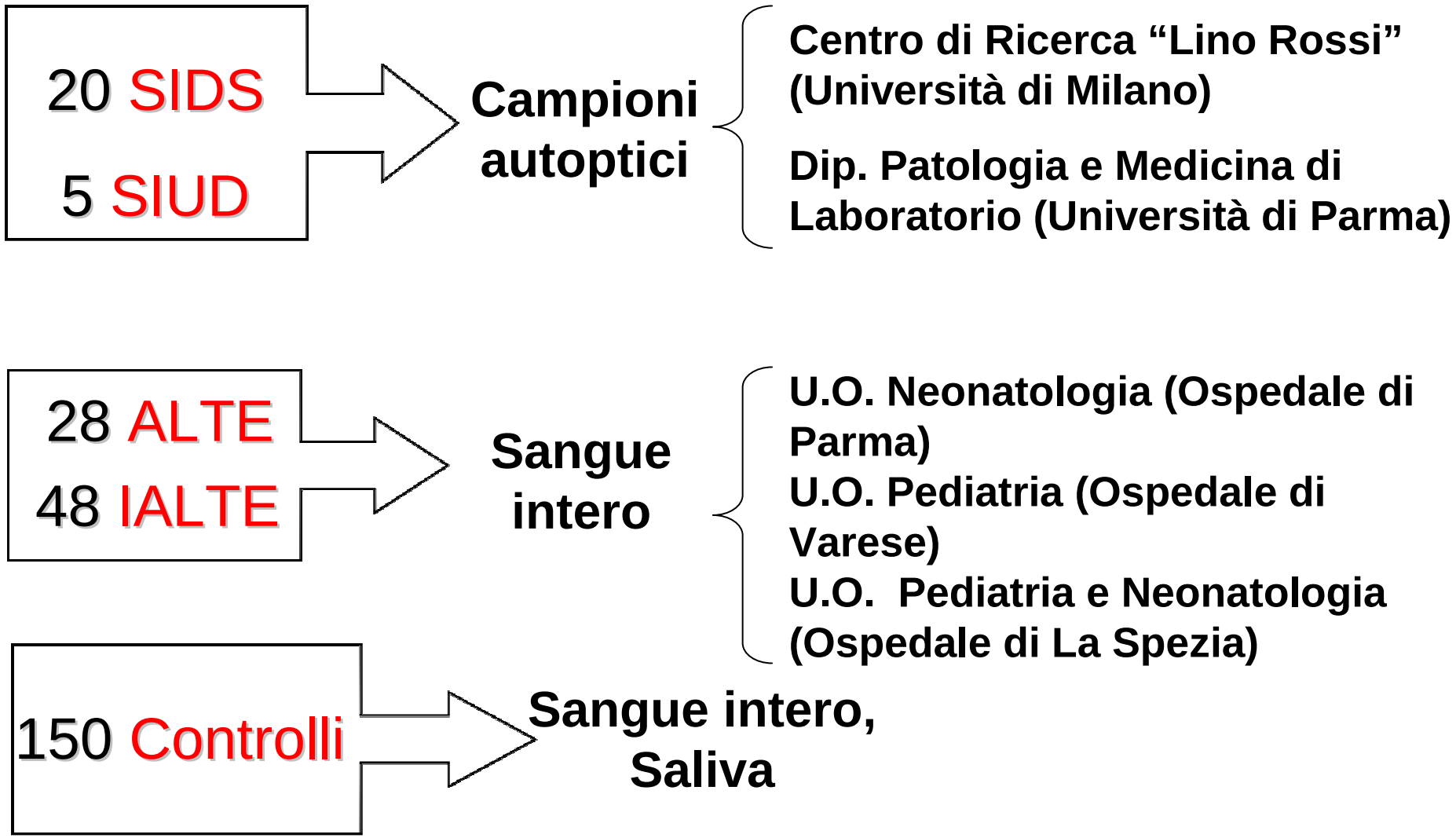


Affinità patogenetica
CARDIACA - ARITMOGENA
(Schwartz, 2001)



Telltale electrocardiogram. A sometimes fatal heart arrhythmia called long QT syndrome may underlie some SIDS cases.

Raccolta dei campioni

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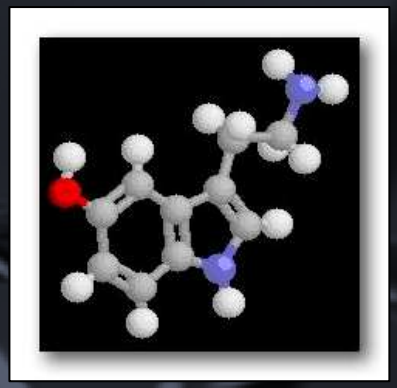
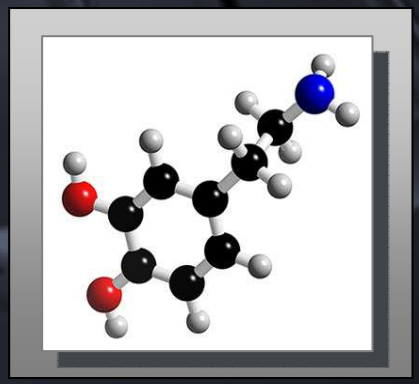
Polimorfismi genici e metabolismo di neurotrasmettitori

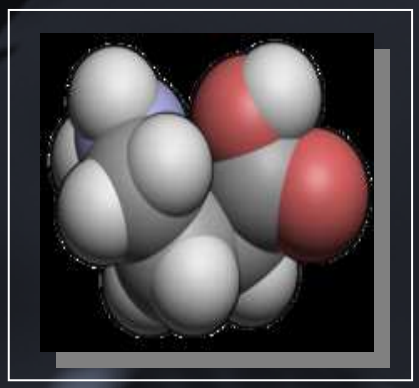
Serotonina



Dopamina

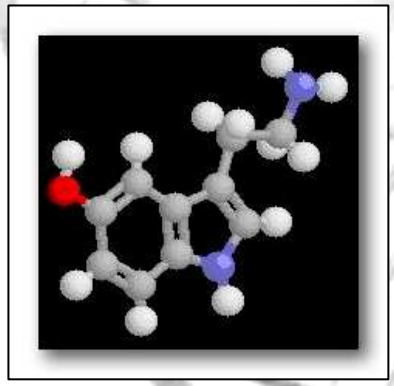


GABA



Polimorfismi genici di neurotrasmettitori

Serotonina



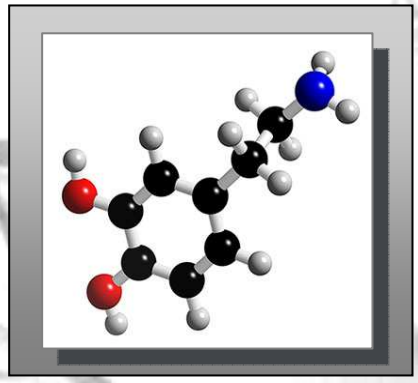
TPH2

5HTT

MAOA

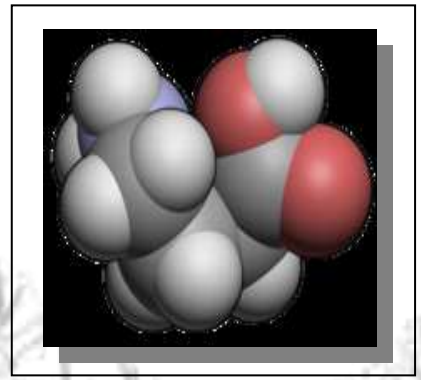
Htr 1a

Dopamina



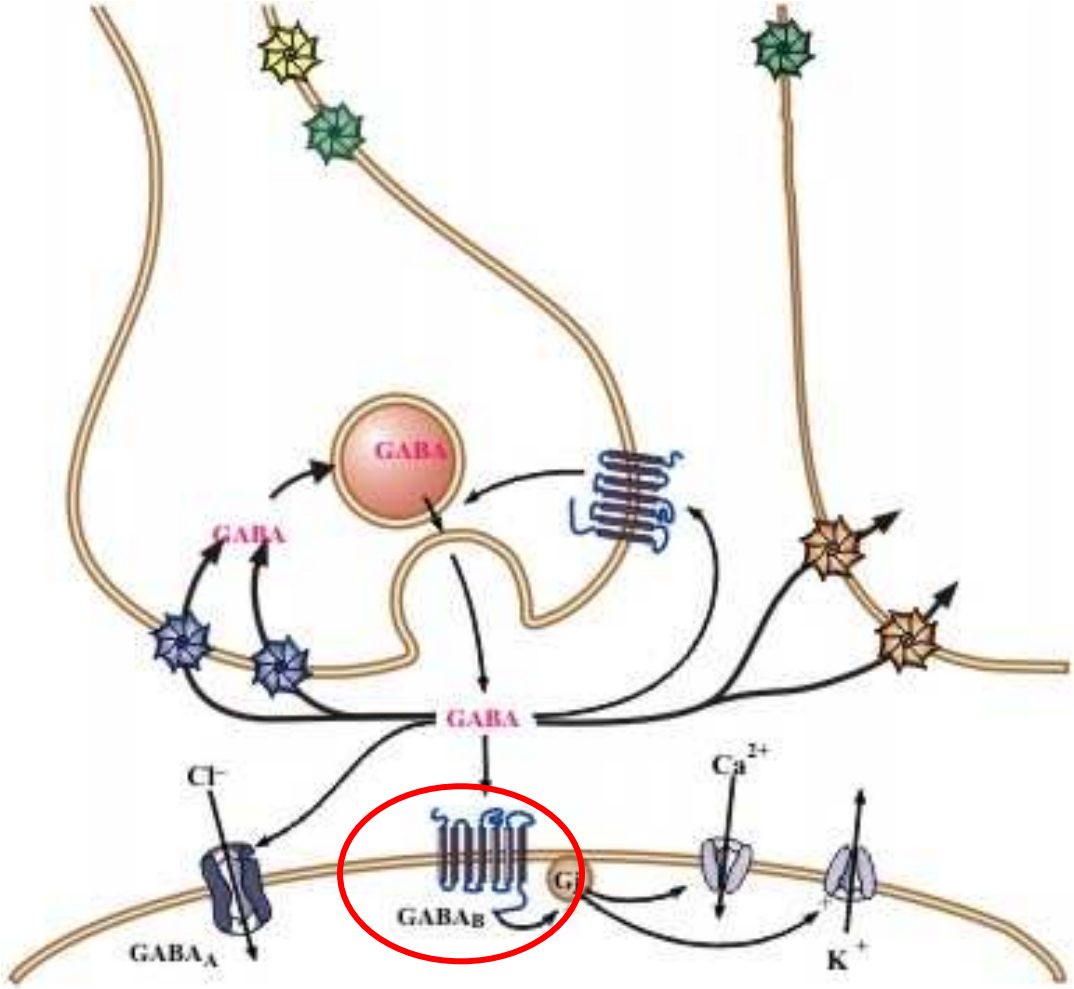
DAT

GABA



GABA(B)R1

GABA(B)R1
Recettore del GABA



Mutazione puntiforme

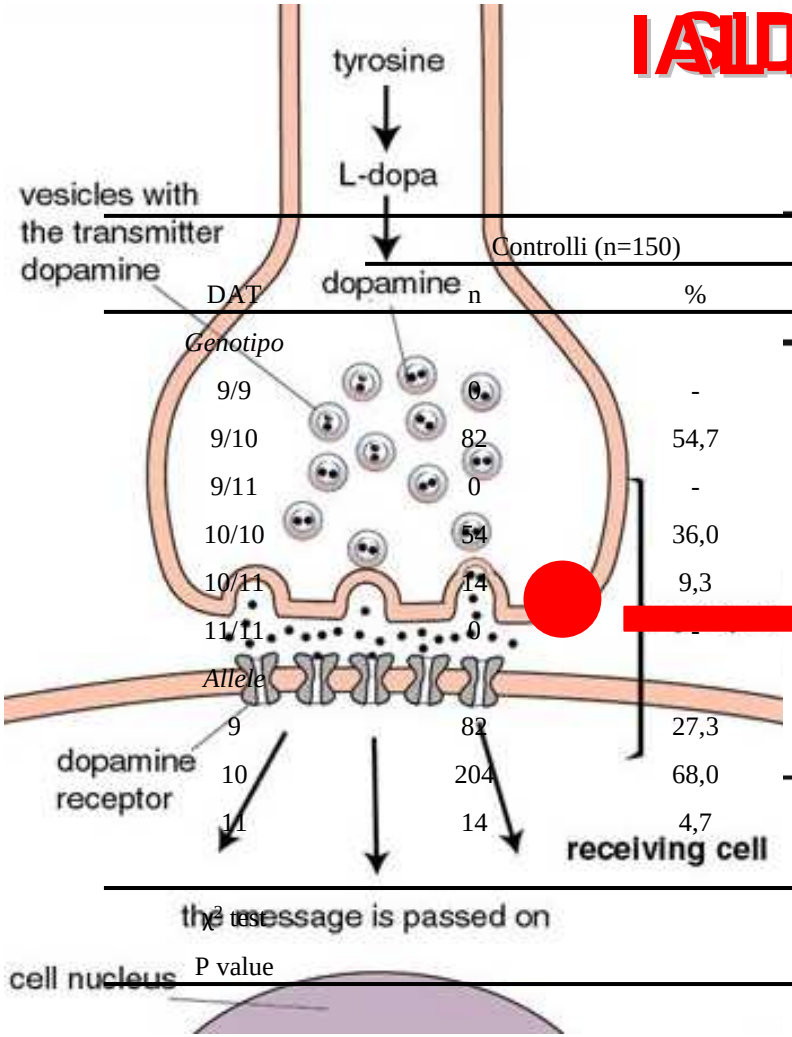
G1465A

Esone 7

espressione del recettore

MAI TROVATA

PATHWAY METABOLICO della DOPAMINA



IALITE e ALITE

DAT - trasportatore della Dopamina

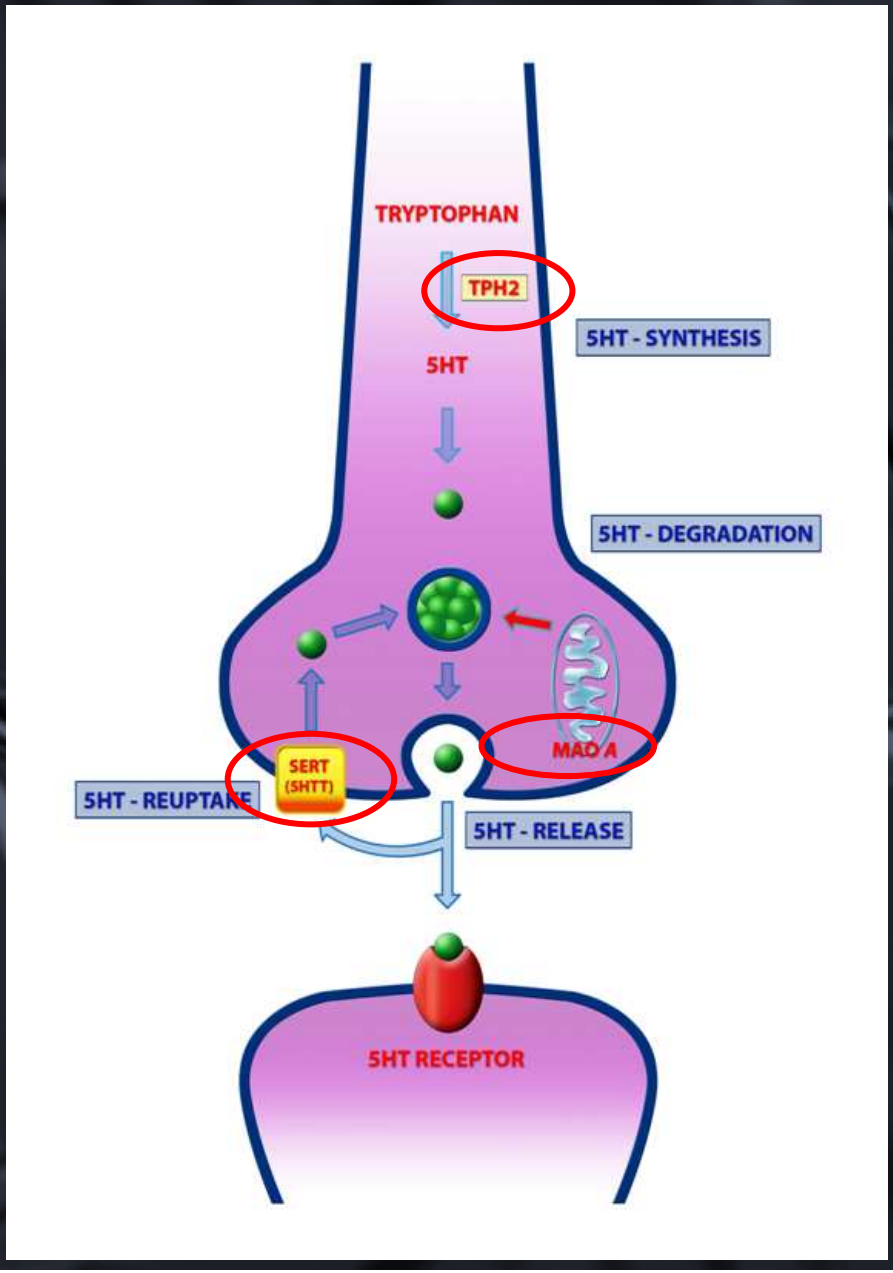
	Controlli (n=150)		SIDS + SIALITE (n=35)		LR ALITE (n=32)		*P* value
DAT	n	%	Number	Percentage	n	%	
Genotipo							
9/9	0	-	4	11,5	2	6,2	0.64
9/10	82	54,7	15	42,8	14	43,8	
9/11	0	-	0	-	0	-	
10/10	54	36,0	15	42,8	15	46,9	
10/11	14	9,3	1	2,9	1	3,1	
11/11	0	-	0	-	0	-	0.86
Allele							
9	82	27,3	23	32,9	9	28,1	
10	204	68,0	46	65,7	45	70,3	
11	14	4,7	1	1,4	1	1,6	
χ^2 test			0,38		0,20		
P value			0,54		0,89		

VNTR - 40 bp (alleli 3-11)

Polimorfismo funzionale

esone 15

PATHWAY METABOLICO della SEROTONINA



TPH2

triptofano idrossilasi 2

SINTESI

5-HTT

trasportatore della serotonina

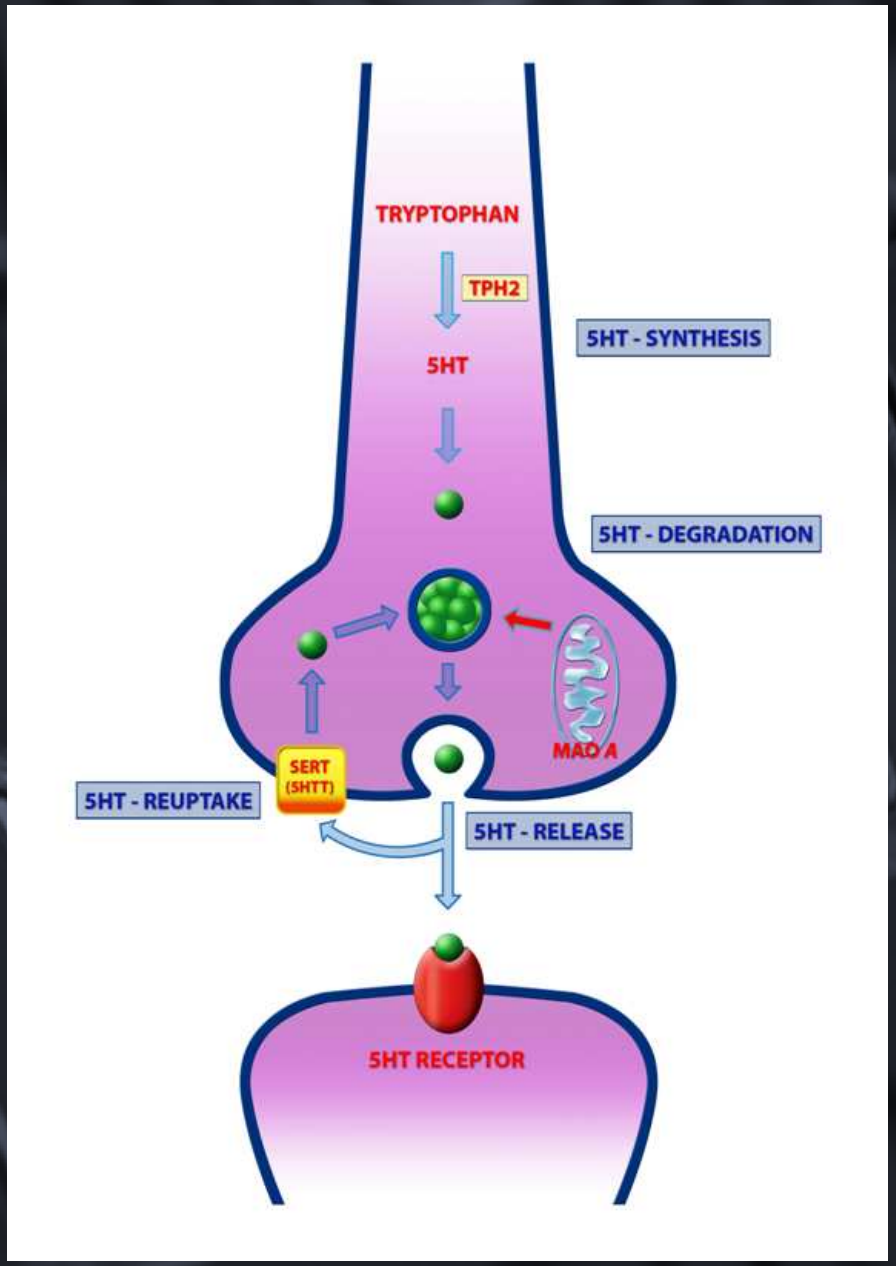
RE-UPTAKE

MAOA

monoamino ossidasi A

DEGRADAZIONE

Serotonin Receptor 1A
Recettore della serotonina



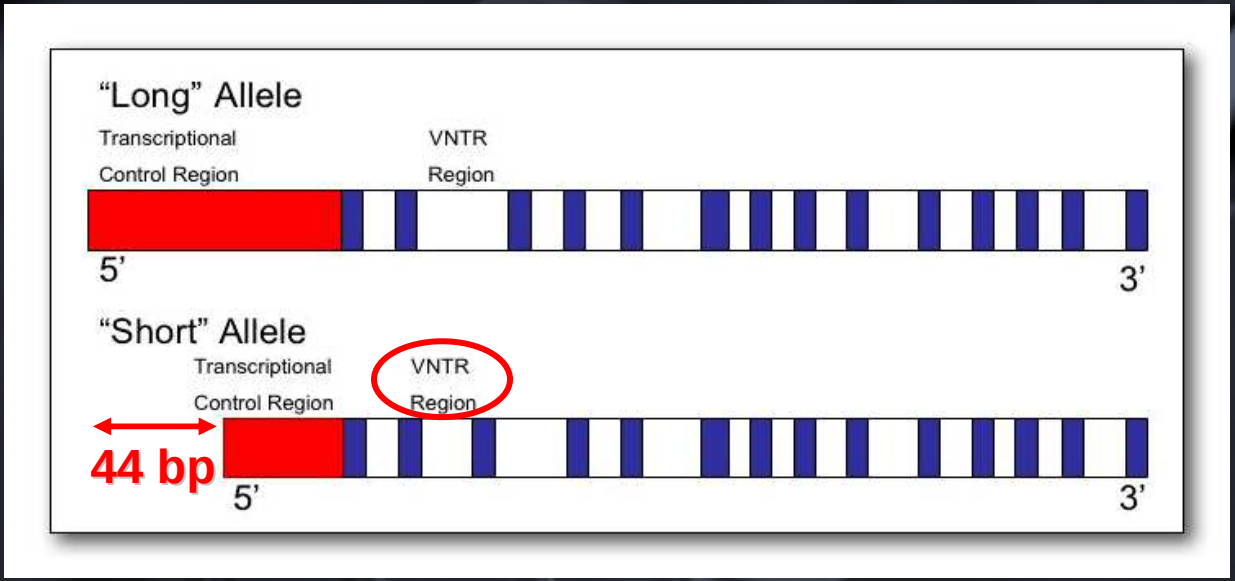
Mutazione puntiforme
1019 C>G

TPH2-triptofano idrossilasi 2

```
SIDS_01    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_02    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_03    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_04    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_05    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_06    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_07    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_08    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_09    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_10    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_11    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_12    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_13    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_14    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_15    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_16    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_17    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_18    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_19    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
SIDS_20    TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
CTR_01     TGCAGGGACTTTGCAAAGTCAATTACCCGTCCCTTCTCAGTATACTTCAATCCCTACACACAG
           ************************************************************
```

G1463A → **R144H** **<u>mai trovata</u>**

5HTT- trasportatore della Serotonina

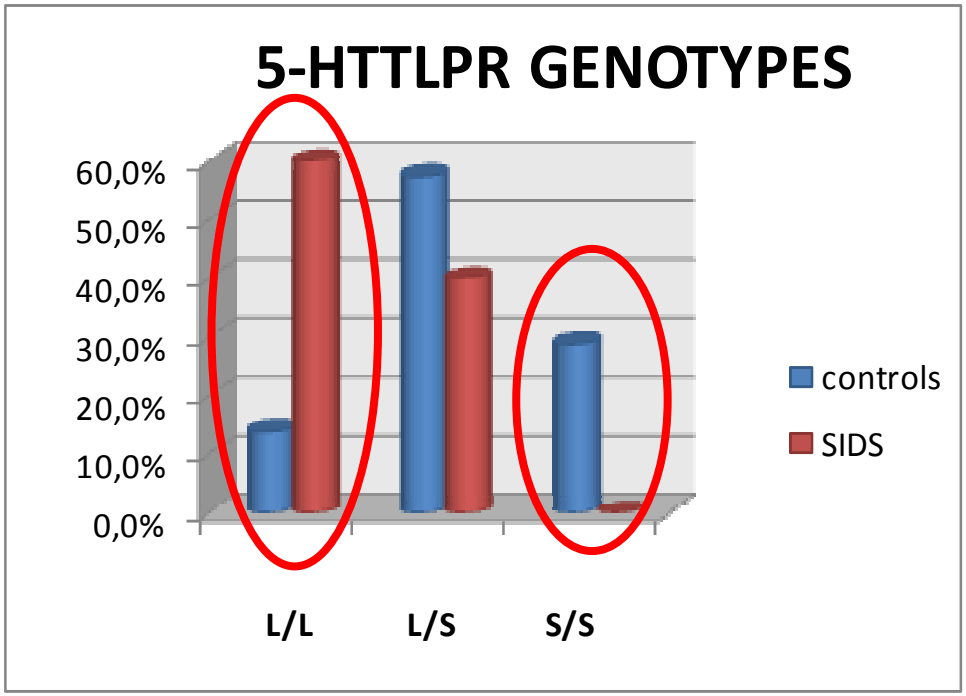


GENOTIPO L/L ***Fattore di rischio***

GENOTIPO S/L
GENOTIPO S/S

5HTTLPR
Frequenze alleliche e genotipiche

SIDS



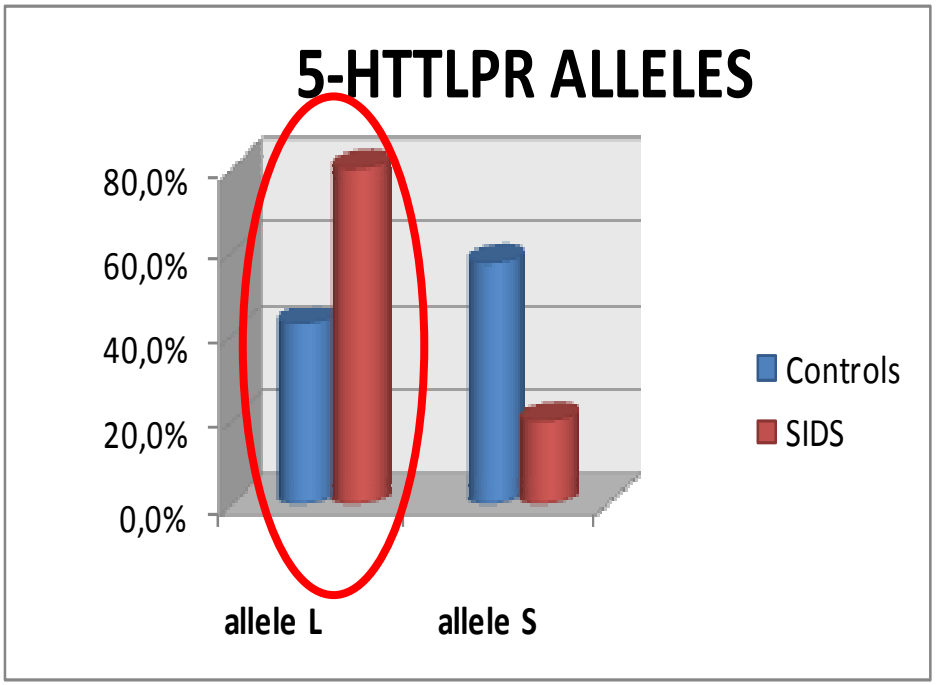
p=0.001

GENOTIPO L/L

60% vs. 14%

SIDS controlli

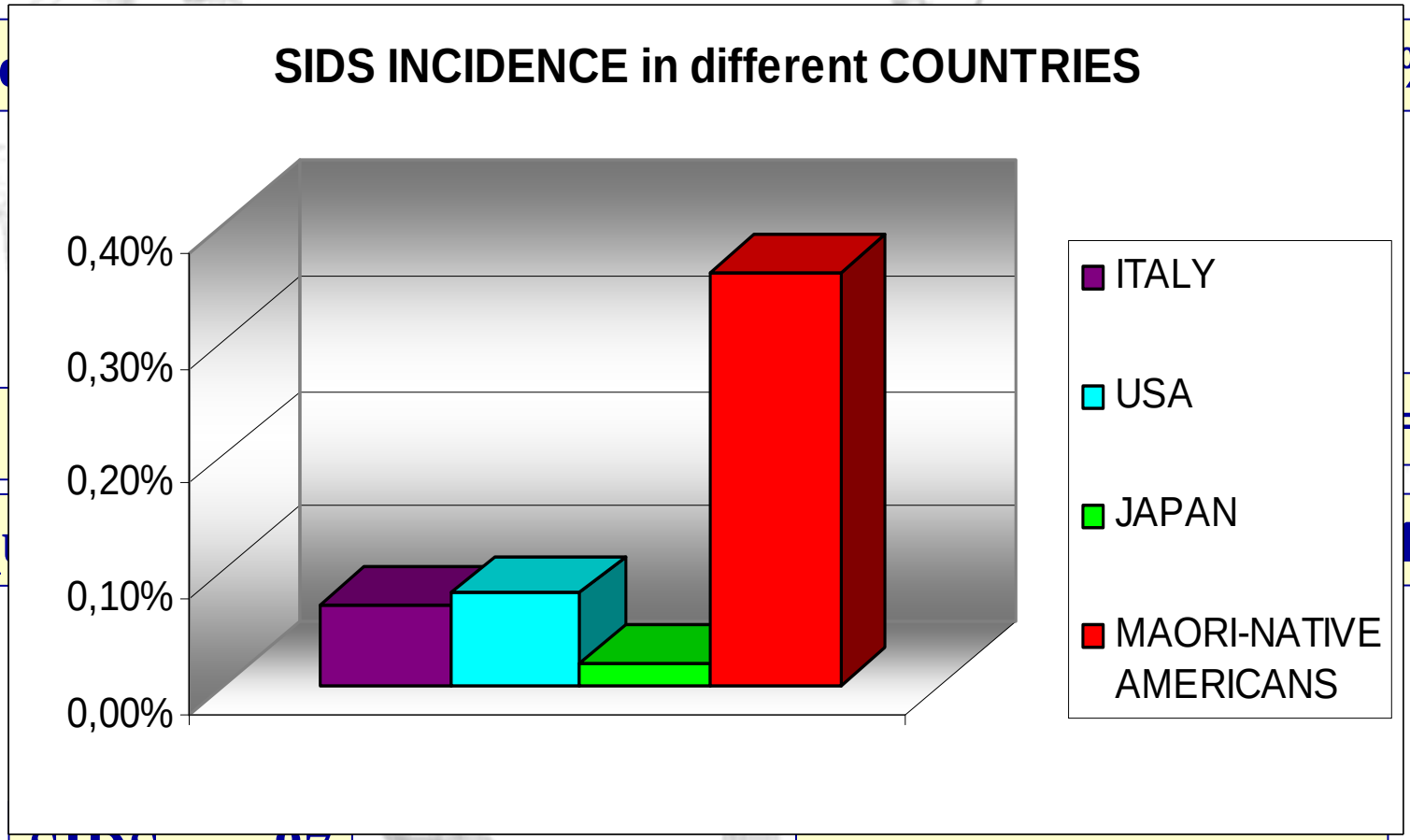
p<0.001



5-HTT FREQUENZE ALLELICHE

SIDS n=20

CONTROLLI n=150



SIDS n=87

Frequenza allele L 73%

CONTROLLI SANI

Frequenza allele L 35%

SEROTONINA (5 Idrossitriptamina)

Neuroni serotoninergici esercitano effetto modulatorio su:

FUNZIONALITA' CARDIOVASCOLARE
TONO MUSCOLARE
RITMO RESPIRATORIO
TERMOREGOLAZIONE
RITMI CIRCADIANI
STATI COMPORTAMENTALI

ORIGINAL ARTICLE

A Serotonin Transporter Gene Promoter Polymorphism (5-HTTLPR) and Prefrontal Cortical Binding in Major Depression and Suicide

J. John Mann, MD; Yung-yu Huang, MS; Mark D. Underwood, PhD; Suham A. Kassir, MS; Sara Oppenheim, PhD; Thomas M. Kelly, PhD; Andrew J. Dwork, MD; Victoria Arango, PhD

Background: Major depression and suicide are associated with fewer serotonin transporter (5-HTT) sites. The 5'-flanking promoter region of the 5-HTT gene has a biallelic insertion/deletion (5-HTTLPR). We assayed prefrontal cortical (PFC) 5-HTT binding in major depression and suicide and examine the relationship to the 5-HTTLPR allele.

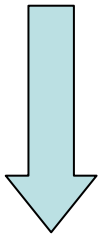
Methods: Postmortem brain samples from 220 individuals were genotyped for the 5-HTTLPR polymorphism. Binding of 5-HTT was assayed by quantitative autoradiography in the PFC of a subset of subjects (n=159). Clinical information, including *DSM-III-R* Axis I diagnoses, was obtained by psychological autopsy and medical chart review.

Results: Binding to 5-HTT was lower in the ventral PFC of suicides compared with nonsuicides and was lower throughout the PFC of subjects with a history of major depression. The 5-HTTLPR genotype was associated with major depression but not with suicide or 5-HTT binding.

Conclusions: A diffuse reduction of 5-HTT binding in the PFC of individuals with major depression may reflect a widespread impairment of serotonergic function consistent with the range of psychopathologic features in major depression. The localized reduction in 5-HTT binding in the ventral PFC of suicides may reflect reduced serotonin input to that brain region, underlying the predisposition to act on suicidal thoughts. The 5-HTTLPR genotype was not related to the level of 5-HTT binding and does not explain why 5-HTT binding is lower in major depression or suicide.

Arch Gen Psychiatry. 2000;57:729-738

SIDS **Genotipo L/L**



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Genes regulating the serotonin metabolic pathway in the brain stem and their role in the etiopathogenesis of the sudden infant death syndrome

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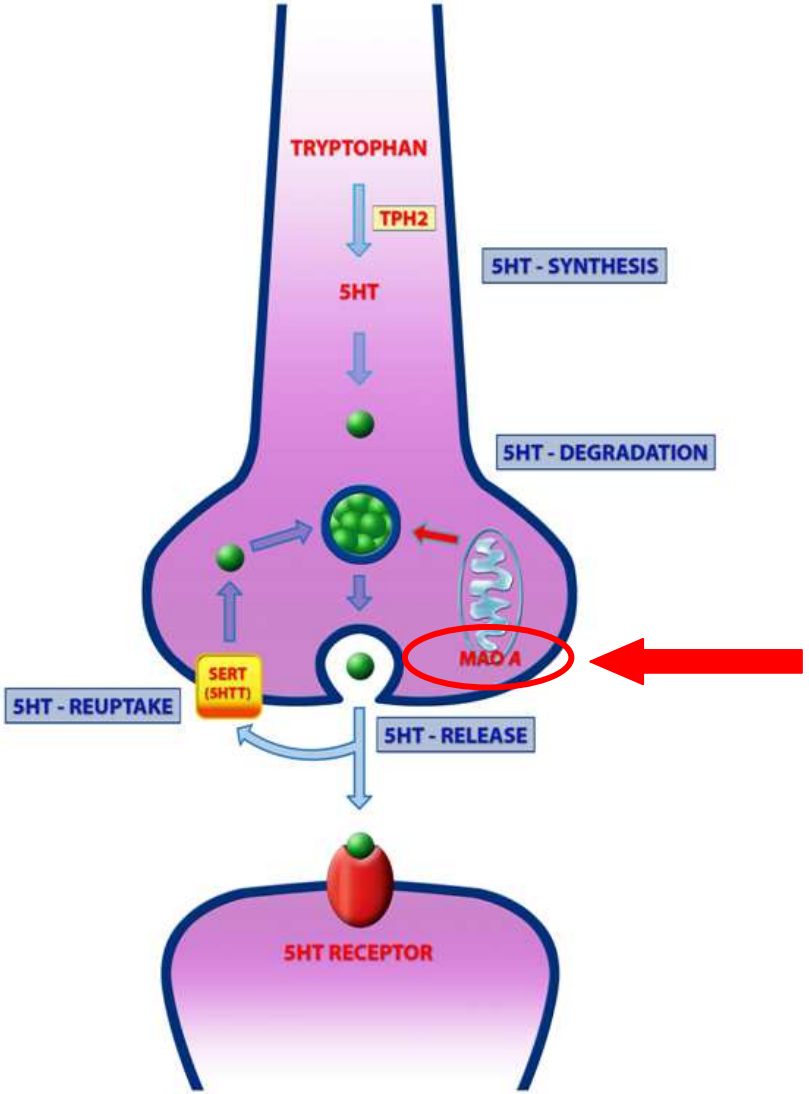
Abstract

Genotypes and allelic frequencies of *TPH2*, *5-HTTLPR*, the *5-HTT* (*SLC6A4*) intron 2 variable-number tandem repeat (VNTR) region, and the *MAOA* VNTR region were determined in brain-stem samples of 20 "genuine" SIDS cases and compared with results obtained from 150 healthy controls. The SNP G1463A responsible for 80% functionality loss of *TPH2* (tryptophan hydroxylase 2) was not detected, neither in SIDS infants nor in the controls. In contrast, a strict relation was found between the *5-HTTLPR* genotype and its allelic frequencies with SIDS cases. The L/L genotype and the long allele (L) of the promoter region of the serotonin transporter were significantly associated (likelihood ratio (LR) test, $p<0.001$) with the syndrome (L/L, 60% SIDS vs 14% controls; L, 80% SIDS vs 42.6% controls). Polymorphisms of the intron 2 VNTR of the same gene showed a trend for significant differences between genotypes 10/10 and 12/12 (LR test, $p=0.068$), with the L-12 haplotype being almost twofold in SIDS (44.5%) with respect to controls (23.4%). Differences were even higher considering the genotype combination L/L-12/12 (20% SIDS vs 2.6%), and variations among categories were statistically highly significant ($p<0.001$). Although additional differences were observed in the frequency of the *MAOA* (monoamine oxidase A) VNTR genotype 3R/3R between SIDS and controls (respectively 15% vs 26%), the results were not supported by statistical significance. Molecular polymorphisms are discussed considering their functional role in regulating serotonin synthesis (*TPH2*), neuronal reuptake (*5-HTTLPR* and *5-HTT* intron 2), and catabolism (*MAOA*) in the nervous system of Italian SIDS infants. Comparisons are made with previous data obtained in different ethnic groups.

Keywords: *5-HTT*; *MAOA*; *TPH2*; Molecular polymorphisms; SIDS; Neurotransmitter

MAOA - monoamine oxidase A



***MAOA* VNTR**

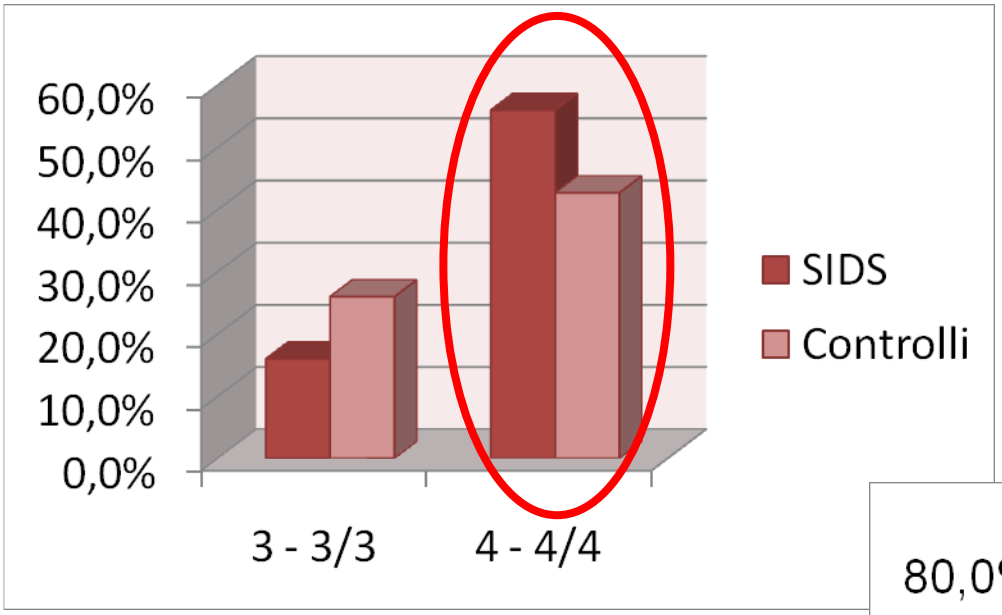
2, 3, 3.5, 4, 5 repeats

polimorfismo funzionale

PROMOTORE

MAOA
Frequenze genotipiche e alleliche

SIDS



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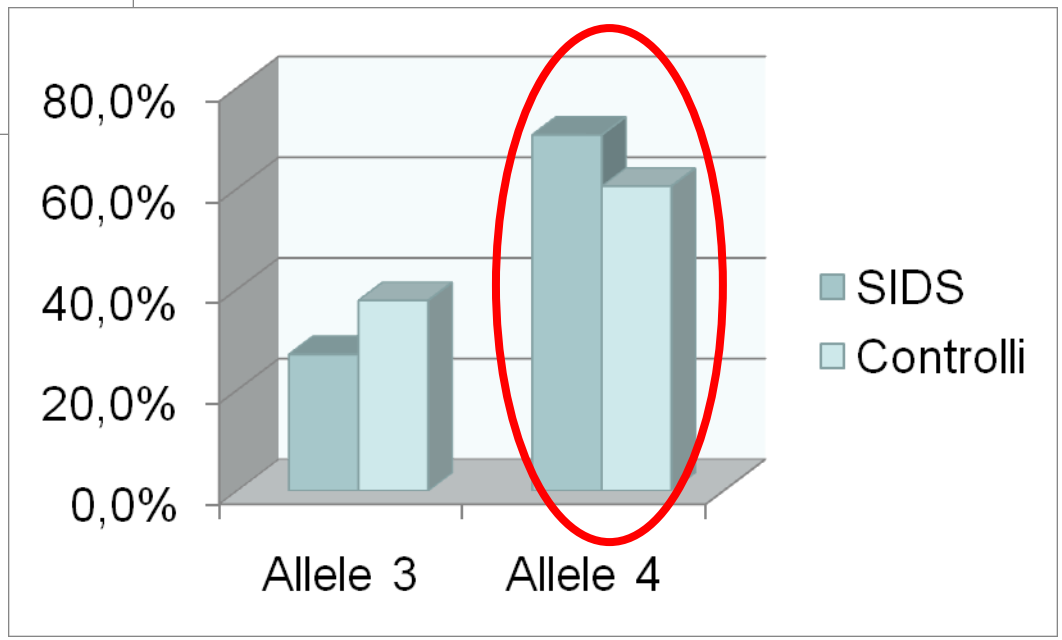

p=0.018

Neurogenetics
DOI 10.1007/s10048-008-0149-x

ORIGINAL ARTICLE

Association of dopamine transporter and monoamine oxidase molecular polymorphisms with sudden infant death syndrome and stillbirth: new insights into the serotonin hypothesis

Laura Filonzi · Cinzia Magnani · Anna Maria Lavezzi · Guido Rindi · Stefano Parmigiani · Giulio Bevilacqua · Luigi Matturri · Francesco Nonnis Marzano

Neurogenetics
DOI 10.1007/s10048-010-0257-2

LETTER TO THE EDITORS

Confirmed association between monoamine oxidase A molecular polymorphisms and Sudden Infant Death Syndrome

Laura Filonzi · Cinzia Magnani · Francesco Nonnis Marzano

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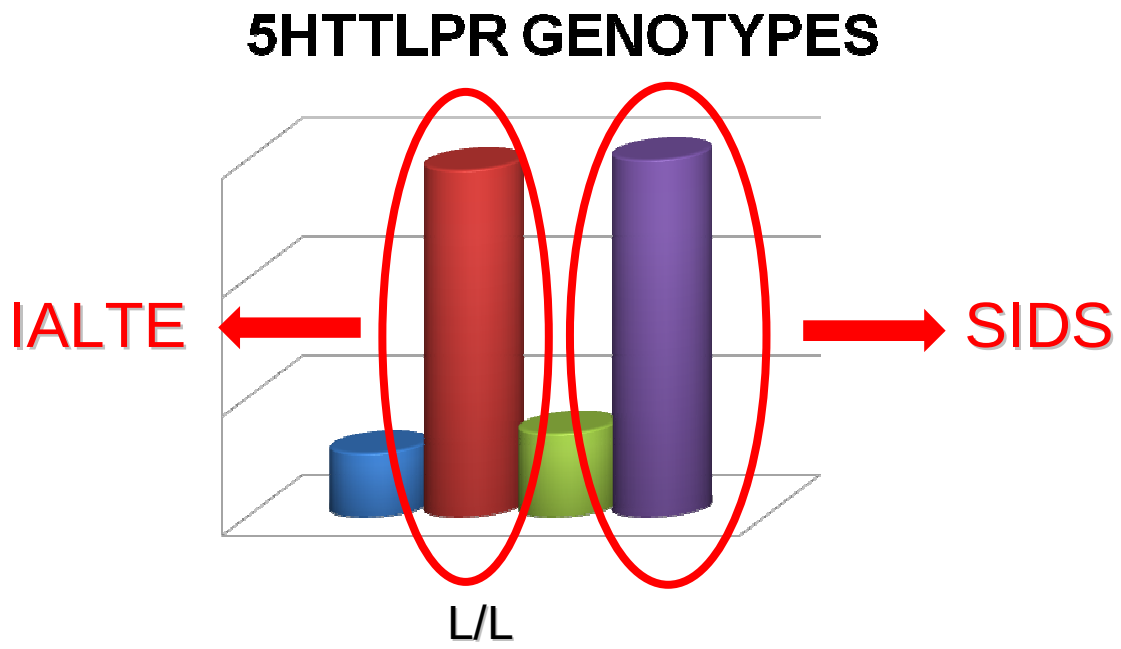
5HTTLPR
Frequenze genotipiche

ALTE e IALTE



GENOTIPO L/L

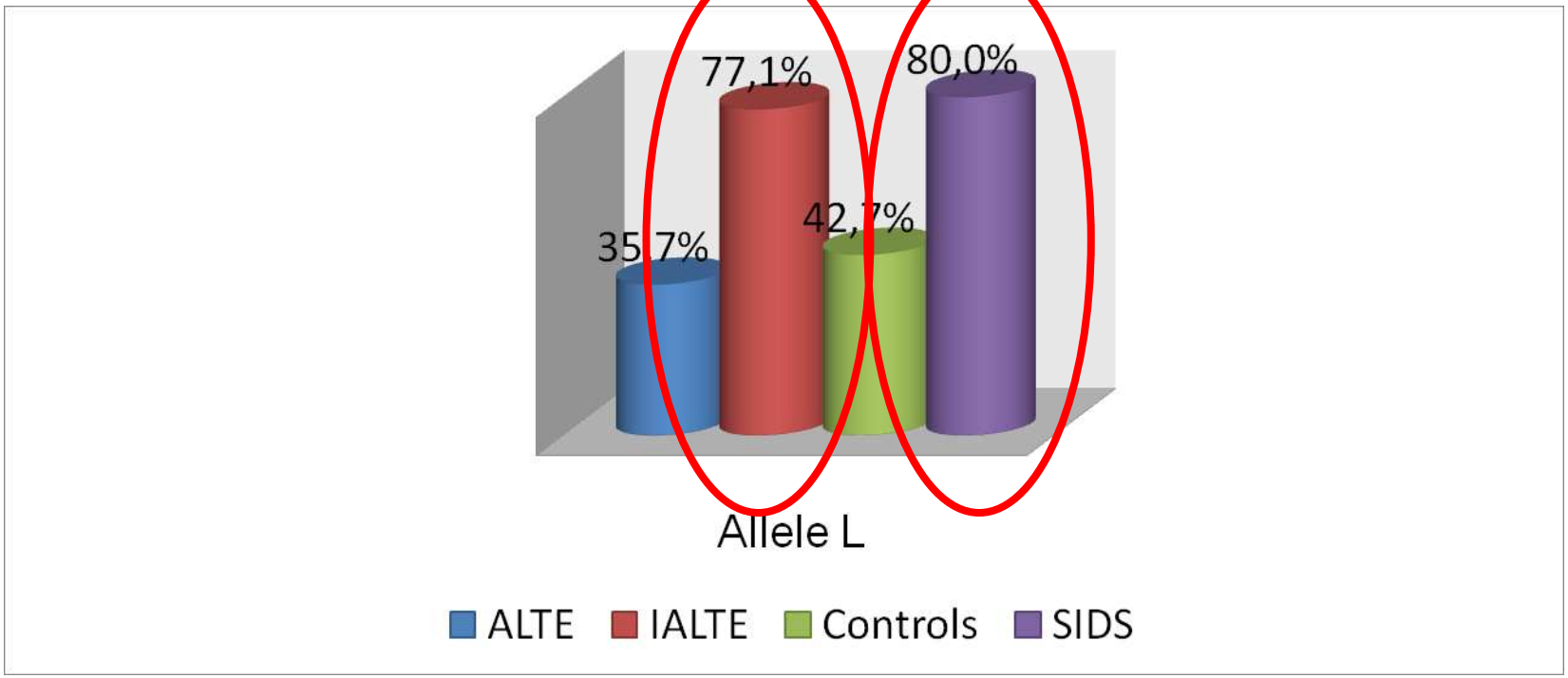
10.7 % ALTE

58.3% IALTE

Vs. 14% controlli

5HTTLPR
Frequenze alleliche

ALTE e IALTE



Allele L

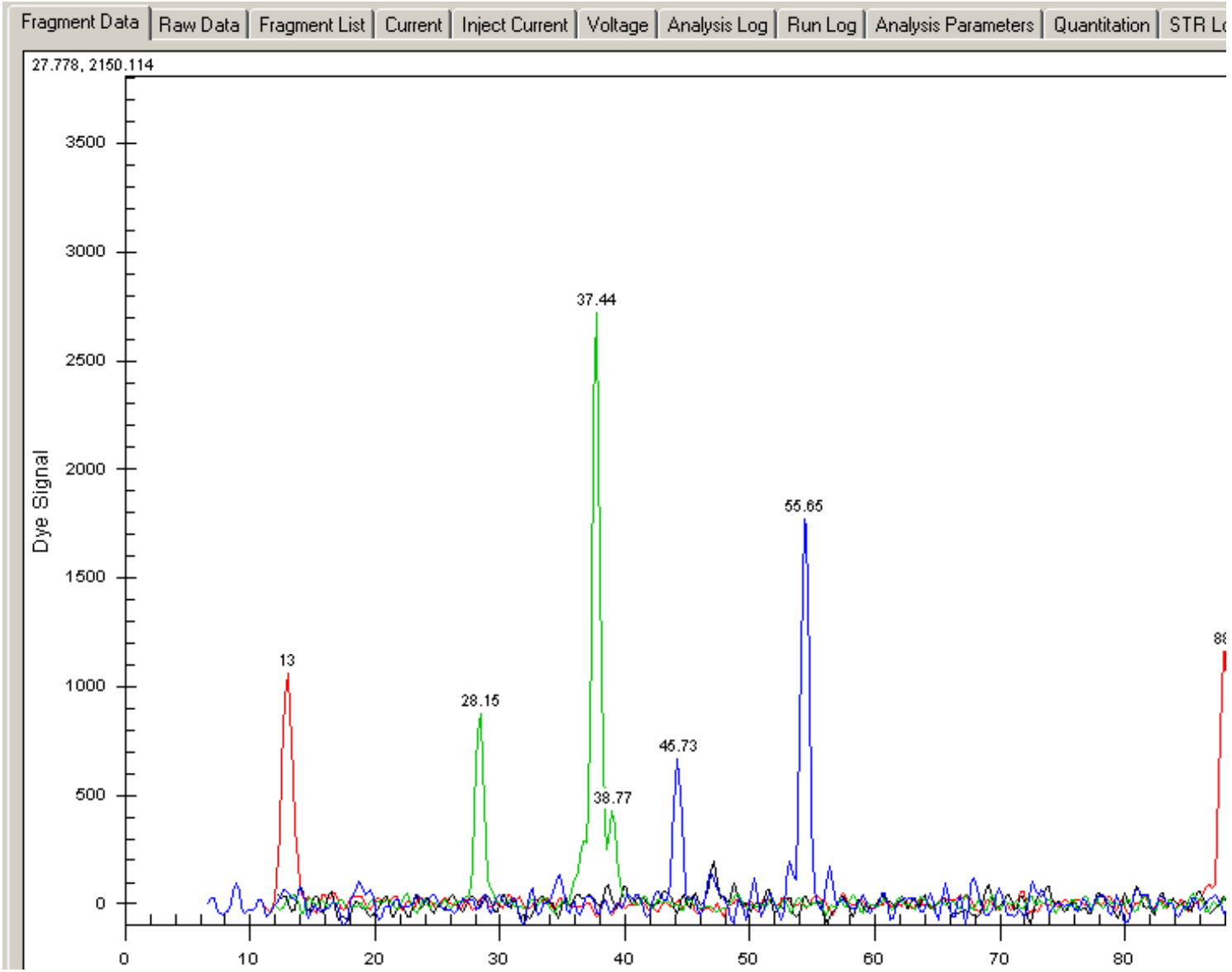
35,7 % ALTE

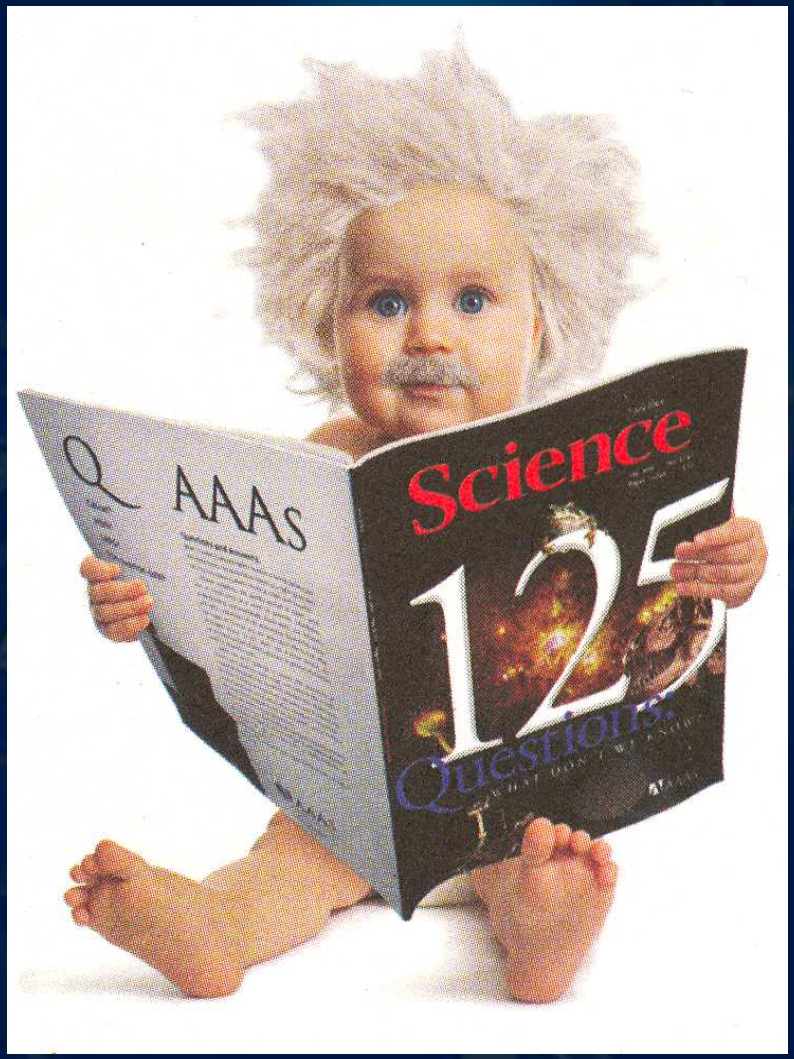
77,1 % IALTE

Vs. 42,7% controlli

SINDROME DEL QT-LUNGO

Geni KVLQT1, HERG, SNC5A, KCNE1 e KCNE2





In collaborazione con

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