

$^{99}\text{Tc}^{\text{m}}$ -MIBI亲肿瘤显像对甲状腺结节的诊断价值

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【摘要】目的:探讨 $^{99}\text{Tc}^{\text{m}}$ -甲氧基异丁基异腈($^{99}\text{Tc}^{\text{m}}$ -MIBI)甲状腺亲肿瘤显像对甲状腺结节良恶性的鉴别诊断价值。**方法:**回顾性分析165例经超声诊断为甲状腺结节,且接受手术治疗获得病理诊断的患者,所有患者先进行 $^{99}\text{Tc}^{\text{m}}\text{O}_4^-$ 甲状腺显像,依据图像判断“冷结节”或“凉结节”,次日进行 $^{99}\text{Tc}^{\text{m}}$ -MIBI甲状腺亲肿瘤显像,包括早期显像和延迟显像。以早期显像或/和延迟显像原“冷/凉结节”部位出现异常摄取,判断为阳性。并以ROI技术测定结节部位 $^{99}\text{Tc}^{\text{m}}$ -MIBI的摄取T/N比值。对甲状腺癌结节按长径分组,计算各组的显像阳性率。以病理结果为标准,计算 $^{99}\text{Tc}^{\text{m}}$ -MIBI显像检查的灵敏度、特异性、阳性预测值、阴性预测值和准确度,甲状腺癌组早期显像和延迟显像之间T/N比值的比较、甲状腺癌和甲状腺良性结节之间早期显像和延迟显像T/N比值的比较,采用 t 检验。不同结节大小组别之间显像阳性率的比较,采用Chi-Square检验。**结果:**165例患者,手术后病理证实甲状腺癌97例,甲状腺良性病变68例, $^{99}\text{Tc}^{\text{m}}$ -MIBI显像对甲状腺结节的诊断灵敏度为84.5%(82/97),特异性为76.4%(52/68),阳性预测值为83.6%(82),阴性预测值为77.6%(52),准确度为81.2%(134/165)。在甲状腺癌,早期显像结节T/N比值($t=2.706\ 6$, $P<0.005$)以及延迟显像T/N比值($t=2.398\ 1$, $P<0.01$),均显著高于甲状腺良性病变组。甲状腺癌结节长径 $\geq 20\ \text{mm}$ 组阳性检出率74.1%, $\geq 30\ \text{mm}$ 组为91.6%,长径 $\geq 30\ \text{mm}$ 组和20~29 mm组比较,阳性检出率未见显著性差异($\chi^2=3.575\ 9$, $P>0.05$),但20~29 mm组比10~19 mm组($\chi^2=3.857\ 1$, $P<0.05$)以及 $<10\ \text{mm}$ 组($\chi^2=8.851\ 7$, $P<0.01$)阳性检出率明显提高。**结论:** $^{99}\text{Tc}^{\text{m}}$ -MIBI甲状腺亲肿瘤显像,对甲状腺结节具有较好的诊断价值,与甲状腺良性病变比较,甲状腺癌对 $^{99}\text{Tc}^{\text{m}}$ -MIBI的摄取更多。当甲状腺癌结节长径大于20 mm,诊断阳性率高,结节大小是影响甲状腺癌诊断灵敏度的重要因素。

【关键词】甲状腺结节;放射性核素显像;体层摄影术;发射型计算机断层成像;单光子; $^{99}\text{Tc}^{\text{m}}$ -甲氧基异丁基异腈

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Diagnostic value of technetium-99m methoxy-isobutyl-isonitrile for thyroid nodules

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Abstract: Objective To evaluate the value of radionuclide imaging with technetium-99m methoxy-isobutyl-isonitrile ($^{99}\text{Tc}^{\text{m}}$ -MIBI) for the differential diagnosis of benign and malignant thyroid nodules. **Methods** A total of 165 patients with thyroid nodules confirmed by ultrasound and pathological diagnosis postoperatively were included in the study. All patients received $^{99}\text{Tc}^{\text{m}}\text{O}_4^-$ thyroid imaging and the "cold or cool nodules" were judged based on the image. $^{99}\text{Tc}^{\text{m}}$ -MIBI thyroid imaging, including early imaging and delayed imaging, was performed the next day. Early imaging or/and delayed imaging showed abnormal uptake of $^{99}\text{Tc}^{\text{m}}$ -MIBI on the original "cold /cool nodules", which was assessed to be positive. The uptake T/N ratio of $^{99}\text{Tc}^{\text{m}}$ -MIBI at the nodules was determined by region-of-interest technique. Thyroid cancer nodules were grouped according to their lengths and diameters, and the positive detection rate of each group was calculated. On the basis of pathological results, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of $^{99}\text{Tc}^{\text{m}}$ -MIBI thyroid imaging were calculated. The T/N ratio of nodules between early imaging and delayed imaging in thyroid cancer group, and the T/N ratio of nodules in early imaging and delayed imaging between thyroid cancer and benign thyroid nodules were compared by t -test. The positive detection

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rates of different nodule size groups were compared by Chi-Square test. **Results** Among the 165 patients, 97 were diagnosed with thyroid cancer and 68 were diagnosed with benign thyroid nodules by postoperative pathology. The diagnostic sensitivity, specificity, positive predictive value, negative predictive value and accuracy of ⁹⁹Tc^m-MIBI imaging for thyroid nodules was 84.5% (82/97), 76.4% (52/68), 83.6%(82/98), 77.6%(52/67) and 81.2%(134/165), respectively. The T/N ratios in the early imaging and delayed imaging of thyroid cancer were significantly higher than those of benign thyroid nodules ($t=2.706\ 6$, $P<0.005$; $t=2.398\ 1$, $P<0.01$). For the thyroid cancer nodule grouped according to their lengths (≤ 10 mm, 10-19 mm, 20-29 mm and ≥ 30 mm groups), the positive detection rate of thyroid cancer nodules was 74.1% in 20-29 mm group and 91.6% in ≥ 30 mm group. There was no statistical differences in positive detection rate between 20-29 mm group and ≥ 30 mm group ($\chi^2=3.575\ 9$, $P>0.05$), but the positive detection rate of 20-29 mm group was significantly higher than that of 10-19 mm group ($\chi^2=3.857\ 1$, $P<0.05$) and that of <10 mm group ($\chi^2=8.851\ 7$, $P<0.01$). **Conclusion** ⁹⁹Tc^m-MIBI thyroid imaging has a good diagnostic value for thyroid nodules. Compared with benign thyroid lesions, thyroid cancer has a higher uptake of ⁹⁹Tc^m-MIBI. When the length of thyroid cancer nodules are greater than 20 mm, a high positive rate of diagnosis can be obtained, and the size of nodules is an important factor affecting the diagnostic sensitivity of thyroid cancer.

Keywords: thyroid nodule; radionuclide imaging; tomography; emission computed tomography; single photon; technetium-99m methoxy-isobutyl-isonitrile

前言

甲状腺结节是临床常见疾病,近年来随着人们健康意识的加强和健康体检的日益增加,甲状腺结节的发现率提高^[1]。甲状腺结节良恶性的鉴别,对治疗方法的选择具有重要意义。⁹⁹Tc^m-甲氧基异丁基异肟(⁹⁹Tc^m-MIBI)作为一种传统的亲肿瘤显像剂,具有理想的理化特性,图像质量好,易于开展,有较好的检查性价比,适合所有配备SPECT的核医学单位应用等优点^[2-3]。本研究回顾性分析165例甲状腺结节的⁹⁹Tc^m-MIBI亲肿瘤显像,并与病理结果对照,以探讨⁹⁹Tc^m-MIBI亲肿瘤显像对甲状腺结节的鉴别诊断价值,现将结果报道如下。

1 资料与方法

1.1 研究对象

回顾性选取2012年1月至2016年12月于广东省第二人民医院临床拟诊断为甲状腺结节的患者165例。其中,男36例,女129例;年龄21~65岁,平均年龄(45.6±12.4)岁。纳入标准:①超声检查发现甲状腺结节;②行⁹⁹Tc^mO₄甲状腺静态显像,显示为“冷结节”或“凉结节”;③行甲状腺⁹⁹Tc^m-MIBI亲肿瘤显像;④经手术治疗,获得病理学诊断。

1.2 ⁹⁹Tc^mO₄甲状腺显像

检查当日患者无需空腹准备。静脉注射⁹⁹Tc^mO₄ 185 MBq,20 min后采集前位甲状腺静态像,显像仪器为GE Hawkeye双探头SPECT/CT,配低能高分辨平行孔准直器,矩阵256×256,能峰140 keV,窗宽20%,采集计数5×10⁵。根据结节的放射性分布是否高于、相近或低于周围正常甲状腺组织,或无放射性分布,将结节分为热结节、温结节、凉结节和冷结节^[4]。图像判读由2名中级职称以上医师独立完成。

1.3 ⁹⁹Tc^m-MIBI亲肿瘤显像

于⁹⁹Tc^mO₄甲状腺显像第2天,进行⁹⁹Tc^m-MIBI亲肿瘤显像,患者无需空腹准备。静脉注射⁹⁹Tc^m-MIBI 740 MBq,15~30 min进行早期显像,2 h进行延迟显像。采集条件为前后位静态像,显像仪器为GE Hawkeye双探头SPECT/CT,配低能高分辨平行孔准直器,矩阵256×256,能峰140 keV,窗宽20%,定时采集5 min。

1.4 ⁹⁹Tc^m-MIBI亲肿瘤显像图像判读标准

将⁹⁹Tc^m-MIBI显像与⁹⁹Tc^mO₄甲状腺显像比较,在⁹⁹Tc^mO₄甲状腺显像出现冷/凉结节部位,是否存在异常⁹⁹Tc^m-MIBI摄取。在早期显像或/和延迟显像,若冷/凉结节部位出现⁹⁹Tc^m-MIBI摄取高于周围正常甲状腺组织,判断为阳性,若结节部位⁹⁹Tc^m-MIBI摄取低于或近似于周围正常甲状腺组织,则判断为阴性^[5]。图像判断由2位中级职称以上医师独立完成。

1.5 ⁹⁹Tc^m-MIBI亲肿瘤显像T/N比值测定

参照文献^[6],在早期显像和延迟显像,分别以感兴趣区(Region of Interest, ROI)技术勾画肿瘤,并测定ROI内放射性计数,在病灶周围正常组织勾画同样大小ROI并测定其放射性计数,病灶与正常组织ROI内放射性计数的比值,即为病灶对⁹⁹Tc^m-MIBI的摄取比值,即T/N比值。对于甲状腺内有2个以上结节的患者,选最大的结节作为ROI,测定并计算T/N比值^[7]。

1.6 统计学方法

以手术后病理诊断结果作为标准,统计⁹⁹Tc^m-MIBI显像阳性、假阳性、阴性以及假阴性病例数目,并以此计算灵敏度、特异性、准确度、阳性与阴性预测值等诊断效能指标。采用SPSS 13.0软件进行分

析,不同组别间T/N比值的比较采用 t 检验,阳性检出率的比较采用Chi-Square检验, $P<0.05$ 为差异有统计学意义。

2 结果

2.1 病理结果

165例患者中,手术后病理诊断为甲状腺癌97例,其中乳头状癌82例、滤泡状癌13例、未分化癌2例。甲状腺良性病变68例,其中甲状腺腺瘤36例、结节性甲状腺肿19例、甲状腺炎性结节13例。

2.2 图像表现

典型甲状腺癌, $^{99}\text{Tc}^{\text{m}}\text{O}_4$ 甲状腺显像表现为“冷结节”或“凉结节”, $^{99}\text{Tc}^{\text{m}}$ -MIBI在早期显像和延迟显像,结节部位表现为异常浓聚影(图1)。但也有部分甲状腺癌患者, $^{99}\text{Tc}^{\text{m}}$ -MIBI早期显像为异常浓聚影,而延迟显像结节部位未见异常浓聚。而典型的甲状腺良性病变,如甲状腺腺瘤, $^{99}\text{Tc}^{\text{m}}\text{O}_4$ 甲状腺显像表现为“冷结节”,但 $^{99}\text{Tc}^{\text{m}}$ -MIBI早期显像和延迟显像,结节部位均未见明显放射性摄取(图2)。

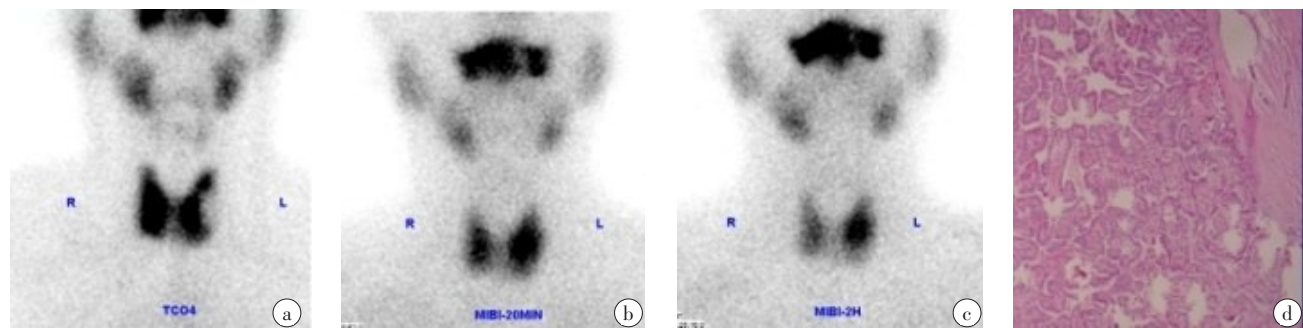


图1 $^{99}\text{Tc}^{\text{m}}$ -MIBI甲状腺亲肿瘤显像阳性病例

Fig.1 A case of $^{99}\text{Tc}^{\text{m}}$ -MIBI thyroid imaging with positive results

a:甲状腺左叶中部结节, $^{99}\text{Tc}^{\text{m}}\text{O}_4$ 甲状腺显像为“冷结节”;b: $^{99}\text{Tc}^{\text{m}}$ -MIBI早期显像,原“冷结节”部位可见异常摄取,T/N比值为3.2;c: $^{99}\text{Tc}^{\text{m}}$ -MIBI延迟显像,“冷结节”部位可见放射性滞留,T/N比值延迟摄取,T/N比值为3.2,诊断为恶性病变;d:左叶结节术后病理检查图(HE \times 100),示甲状腺乳头状癌

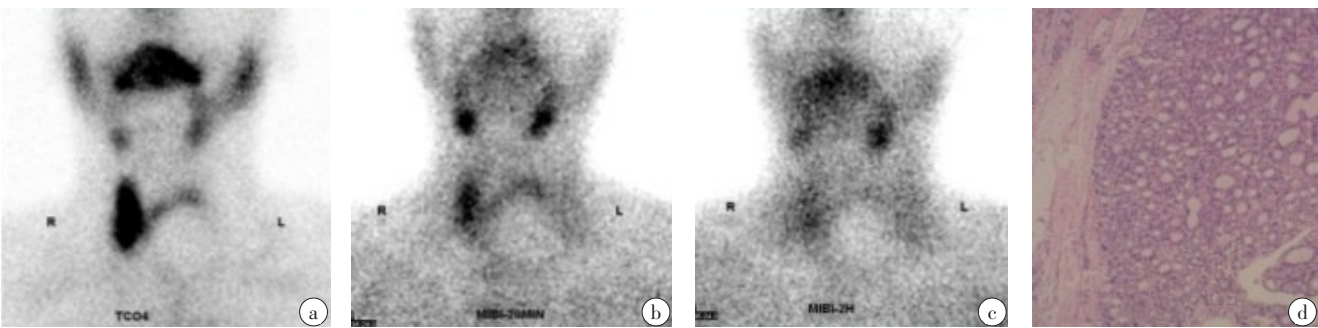


图2 $^{99}\text{Tc}^{\text{m}}$ -MIBI甲状腺亲肿瘤显像阴性病例

Fig.2 A case of $^{99}\text{Tc}^{\text{m}}$ -MIBI thyroid imaging with negative results

a:甲状腺左叶中下极结节,边缘基本光滑整齐, $^{99}\text{Tc}^{\text{m}}\text{O}_4$ 甲状腺显像为“冷结节”;b: $^{99}\text{Tc}^{\text{m}}$ -MIBI早期显像,原“冷结节”部位未见异常摄取;c: $^{99}\text{Tc}^{\text{m}}$ -MIBI延迟显像,“冷结节”部位未见放射性滞留,显像表现阴性,诊断为甲状腺良性结节;d:左叶结节手术后病理检查图(HE \times 100),示甲状腺滤泡性腺瘤

2.3 诊断效能分析

在97例甲状腺癌患者中, $^{99}\text{Tc}^{\text{m}}$ -MIBI早期显像和延迟显像均表现为阳性70例;8例患者仅早期显像为阳性,而延迟显像为阴性;另有4例仅延迟显像为阳性,而早期显像阴性;其余15例甲状腺癌患者, $^{99}\text{Tc}^{\text{m}}$ -MIBI早期和延迟显像,均未见结节部位异常放射性摄取。在68例甲状腺良性病变中,16例表现 $^{99}\text{Tc}^{\text{m}}$ -MIBI异常摄取,为假阳性(表1)。故 $^{99}\text{Tc}^{\text{m}}$ -MIBI显像对甲状腺结节的诊断灵敏度为84.5%(82/97),特异性为76.4%(52/68),阳

性预测值为83.6%(82/98),阴性预测值为77.6%(52/67),准确度为81.2%(134/165)。

2.4 甲状腺癌患者早期显像和延迟显像T/N比值的比较

78例早期显像阳性患者,结节部位 $^{99}\text{Tc}^{\text{m}}$ -MIBI摄取T/N比值为1.4~3.2,平均 2.9 ± 1.4 ;而74例延迟显像阳性患者,结节部位T/N比值为1.2~3.7,平均 3.2 ± 1.5 ,两者之间T/N比值未见统计学差异($t=0.533\ 7$, $P>0.05$)。8例仅早期显像阳性患者,结节T/N比值为1.4~2.9,

表1 ⁹⁹Tc^m-MIBI亲肿瘤显像与病理结果比较
Tab.1 Comparison of results between ⁹⁹Tc^m-MIBI
imaging and pathological examination

⁹⁹ Tc ^m -MIBI显像	病理结果		合计
	阳性	阴性	
阳性	82	16	98
阴性	15	52	67
合计	97	68	165

平均2.8±1.6;4例仅延迟显像阳性患者,结节T/N比值为1.5~3.6,平均2.5±1.7。

2.5 甲状腺癌和甲状腺良性病变T/N比值的比较

甲状腺良性病变患者,11例早期显像和延迟显像均为阳性,3例仅早期显像阳性,延迟显像阴性,2例仅延迟显像阳性,早期显像阴性。累计早期显像阳性共14例,结节部位T/N比值为1.8±1.3。延迟显像阳性者共13例,结节部位T/N比值为2.1±1.6。与甲状腺癌患者组比较,早期显像($t=2.706\ 6, P<0.005$)以及延迟显像($t=2.398\ 1, P<0.01$),良性病变T/N比值均显著低于甲状腺癌组。

2.6 甲状腺癌结节大小对阳性检出率的影响

参照颈部超声检查结果,97例甲状腺癌患者,单发结节56例,2个结节22例,3个以上结节19例。超声检查报告的结节共172个。结节大小以结节长径表示,其中长径<10 mm者12例,10~19 mm者22例,20~29 mm者27例,≥30 mm者36例。随着结节长径增大,⁹⁹Tc^m-MIBI显像阳性率分别为16.7%、40.9%、74.1%和91.6%。结节≥30 mm组阳性率与20~29 mm组无显著差异($\chi^2=3.575\ 9, P>0.05$),结节<10 mm组($\chi^2=8.851\ 7, P<0.01$)以及10~19 mm组($\chi^2=3.857\ 1, P<0.05$)检查阳性率显著低于≥20 mm组。

3 讨论

本研究显示,⁹⁹Tc^m-MIBI作为亲肿瘤显像剂,对甲状腺结节的诊断灵敏度为84.5%,阳性预测值为83.6%,具有较高的检出率。⁹⁹Tc^m-MIBI是一种亲脂性阳离子化合物,由于肿瘤细胞的脂溶性及其所带电荷,MIBI可通过异化扩散被摄取,依赖细胞膜和线粒体膜两侧跨膜电位差而进入细胞,并进入线粒体,其中90%在线粒体聚集。同时,由于病变组织血流丰富,线粒体膜活跃,毛细血管通透性增高,因此而大量摄取⁹⁹Tc^m-MIBI^[8]。本研究有15例甲状腺癌患者,⁹⁹Tc^m-MIBI显像未能检出,出现假阴性,可能与结节位置较深、体积较小,未常规进行断层显像有关。

显像前仔细了解患者结节情况及超声检查结果,适时应用断层显像,可以提高检出阳性率。此外,与肿瘤细胞所处的细胞周期有关,有研究表明⁹⁹Tc^m-MIBI阳性的恶性肿瘤,肿瘤细胞处于细胞周期的G1或G2期,属于细胞快速增殖的阶段^[9]。但如果肿瘤细胞处于有丝分裂的其他阶段,细胞增殖缓慢或静止,可能导致假阴性。还有学者认为,肿瘤组织低血管化、低氧代谢以及肿瘤细胞密度低,可能引起⁹⁹Tc^m-MIBI摄取不足,出现假阴性^[10]。

本研究发现,⁹⁹Tc^m-MIBI甲状腺亲肿瘤显像特异性为76.4%,阴性预测值为77.6%,甲状腺癌和良性甲状腺结节之间,在早期和延迟显像,不同性质病变对⁹⁹Tc^m-MIBI的摄取比值,具有显著差异,这说明⁹⁹Tc^m-MIBI甲状腺亲肿瘤显像,可以较好地鉴别不同性质病变,对于甲状腺结节危险分层,是一种有用的诊断方法^[11]。一般而言,如果结节表现为低摄取,则恶性病变的可能性低,如果结节为高摄取,则恶性病变的可能性大。有研究发现,恶性肿瘤细胞对MIBI的摄取量可达5%~28%,良性组织细胞摄取量仅2%^[6]。有研究表明,临床施行手术的患者,约55%~85%病理确诊为良性结节^[7]。⁹⁹Tc^m-MIBI显像用于结节良恶性的评估,可以根据显像表现决定是否继续随访,减少不必要的手术。本研究有16例良性甲状腺结节,表现为假阳性,有研究认为,体积较大的甲状腺腺瘤、结节性甲状腺肿、甲状腺炎症、高功能腺瘤等,容易出现假阳性^[12]。该类肿瘤往往局部血供丰富,代谢旺盛,增殖水平高,生长快,应该及时手术切除^[13],因此该类病灶即使出现假阳性,但不影响治疗方案的选择。

本研究结果表明,对于大多数甲状腺癌而言,早期显像与延迟显像,二者T/N比值无显著差异,即早期显像阳性,延迟显像也表现为阳性。但有8例患者仅早期显像为阳性,而延迟显像则为阴性。有学者认为,随着注射后时间延长,病灶对⁹⁹Tc^m-MIBI清除加快,大量从细胞内洗脱,从而导致早期显影,而延迟显像放射性分布降低或缺失^[14]。也有研究认为,对于小的病灶,早期显像更好,甚至有些病灶在注射后5 min即可显影,而延迟显像对病灶检测敏感性下降^[15]。有研究发现,认为在60 min显像可以得到最好的肿瘤/本底(T/N)比值^[16]。至于4例患者早期显像阴性,延迟显像阳性,可能与正常甲状腺组织血供状态有关,如血供丰富,⁹⁹Tc^m-MIBI摄取多,可能掩盖肿瘤病灶的摄取而导致假阴性,而随着时间延迟,甲状腺组织内⁹⁹Tc^m-MIBI逐渐洗脱,在延迟显像病灶才得以显示。

本研究发现,随着结节长径增大, ^{99m}Tc -MIBI显像对甲状腺癌结节的检出阳性率明显提高。有研究表明,对于 $\geq 15\text{ mm}$ 的结节,诊断灵敏度为100%,特异性为90.9%^[7],说明结节大小是影响甲状腺癌结节检出率的重要因素。

对甲状腺结节的诊断,颈部彩超一直发挥着主要作用,但是,对于某些腺瘤、炎性结节等,由于回声不典型,使其诊断效能受限^[17]。另一方面,虽然近年来PET/CT应用日益增多,而且我国PET/CT配置政策也进一步放宽,但PET/CT对于甲状腺结节的诊断价值有限,有研究认为,对于甲状腺结节的良恶性鉴别, ^{18}F -FDG PET/CT的诊断效能并不优于 ^{99m}Tc -MIBI显像^[18-19]。因此,对于临床发现甲状腺结节, ^{99m}Tc -MIBI显像表现为“冷结节”,除细针穿刺以外^[20], ^{99m}Tc -MIBI亲肿瘤显像应作为首选评估手段。

【参考文献】

- [1] RAGER O, RADOJEWSKI P, DUMONT R A, et al. Radioisotope imaging for discriminating benign from malignant cytologically indeterminate thyroid nodules[J]. *Gland Surg*, 2019, 8(Suppl 2): s118-s125.
- [2] VERBURG F A, AKTOLUN C, CHITI A, et al. Why the European association of nuclear medicine has declined to endorse the 2015 American thyroid association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer[J]. *Eur J Nucl Med Mol Imaging*, 2016, 43(3): 1001-1005.
- [3] PICCARDO A, PUNTONI M, TREGLIA G, et al. Thyroid nodules with indeterminate cytology: prospective comparison between ^{18}F -FDG-PET/CT, multiparametric neck ultrasonography, ^{99m}Tc -MIBI scintigraphy and histology[J]. *Eur J Endocrinol*, 2016, 174(6): 693-703.
- [4] 范义湘, 彭武和, 石卫民. 甲状腺1小时摄得参数对甲状腺疾病的诊断价值[J]. *临床荟萃*, 1999, 14(21): 980-981.
FAN Y X, PENG W H, SHI W M. The diagnostic value of 1-hour uptake parameters of technetium-99m in thyroid diseases[J]. *Clinical Focus*, 1999, 14(21): 980-981.
- [5] 武军, 张艳霞, 赵树强, 等. ^{99m}Tc -MIBI显像鉴别甲状腺“冷结节”良恶性的临床价值[J]. *中国实用医刊*, 2015, 42(19): 25-26.
WU J, ZHANG Y X, ZHAO S Q, et al. Clinical value of ^{99m}Tc -MIBI imaging in differentiating benign and malignant thyroid cold nodule[J]. *Chinese Journal of Practical Medicine*, 2015, 42(19): 25-26.
- [6] 余会丽, 解洪泉, 王惠君, 等. 核素显像鉴别甲状腺结节良恶性的临床价值分析[J]. *中国现代药物应用*, 2012, 6(2): 5-6.
YU H L, XIE H Q, WANG H J, et al. The clinical value analysis scintigraphy to identify benign and malignant thyroid nodules[J]. *Chinese Journal Modern Drug Application*, 2012, 6(2): 5-6.
- [7] CAMPENNI A, GIOVANELLA L, MASSIMI L, et al. (99m)Tc-methoxy isobutyl isonitrile scintigraphy is a useful tool for assessing the risk of malignancy in thyroid nodules with indeterminate fine needle cytology[J]. *Thyroid*, 2016, 26(8): 1101-1109.
- [8] SCHENKE S, KLETT R, ACKER P, et al. Interobserver agreement of planar and SPECT ^{99m}Tc -MIBI scintigraphy for the assessment of hypofunctioning thyroid nodules[J]. *Nuklearmedizin*, 2019, 58(3): 258-264.
- [9] 龙再颖, 曲新艳, 单英丽. ^{99m}Tc -MIBI显像对甲状腺结节良恶性鉴别诊断价值的研究[J]. *国际放射医学核医学杂志*, 2010, 34(2): 80-83.
LONG Z Y, QU X Y, SHAN Y L. The diagnostic value of ^{99m}Tc -MIBI imaging to benign and malignant thyroid lesions[J]. *Int J Radiat Med Nucl Med*, 2010, 34(2): 80-83.
- [10] CAMPENNI M, SIRACUSA R, RUGGERI L, et al. Differentiating malignant from benign thyroid nodules with indeterminate cytology by ^{99m}Tc -MIBI scan: a new quantitative method for improving diagnostic accuracy[J]. *Sci Rep*, 2017, 7: 6147.
- [11] SAGER S, VATANKULU B, ERDOGAN E, et al. Comparison of ^{18}F -FDG-PET/CT and ^{99m}Tc -MIBI in the preoperative evaluation of cold thyroid nodules in the same patient group[J]. *Endocrine*, 2015, 50(1): 138-145.
- [12] 邱李恒, 林岩松, 李方, 等. ^{99m}Tc -甲氧基异丁基异腈显像在分化型甲状腺癌随访中的应用[J]. *国际放射医学核医学杂志*, 2009, 33(5): 275-278.
QIU L H, LIN Y S, LI F, et al. The value of ^{99m}Tc -Methoxyisobutylisonitrile in follow-up of patients with differentiated thyroid carcinoma[J]. *International Journal of Radiation Medicine Nuclear Medicine*, 2009, 33(5): 275-278.
- [13] 张纯海, 高识, 朱灏宇, 等. ^{99m}Tc -MIBI显像在甲状腺结节诊断中的应用研究[J]. *中国实验诊断学*, 2008, 12(12): 1560-1561.
ZHANG C H, GAO S, ZHU H Y, et al. The research of ^{99m}Tc -MIBI in thyroid nodule diagnosis[J]. *Chinese Journal Laboratory Diagnostic*, 2008, 12(12): 1560-1561.
- [14] 胡疏, 韦伟, 尹为华, 等. ^{99m}Tc -MIBI亲肿瘤显像鉴别甲状腺结节良恶性的临床价值[J]. *罕少疾病杂志*, 2011, 18(3): 7-9.
HU S, WEI W, YIN W H, et al. The value of tumor avid imaging with ^{99m}Tc -MIBI in the differential diagnosis for thyroid nodules[J]. *Journal of Rare and Uncommon Disease*, 2011, 18(3): 7-9.
- [15] MIYAMOTO S, KANJI K, MISAKI T, et al. Evaluation of technetium-99m-MIBI scintigraphy in metastatic differentiated thyroid carcinoma[J]. *J Nucl Med*, 1997, 38(3): 352-356.
- [16] WONG K T, CHOI P T, LEE Y Y, et al. Current role of radionuclide imaging in differentiated thyroid cancer[J]. *Cancer Imaging*, 2008, 10(8): 159-162.
- [17] HAUGEN B R. 2015 American thyroid association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: what is new and what has changed?[J]. *Cancer*, 2017, 123(2): 372-381.
- [18] YORDANOVA A, MAHJOOB S, LINGOHR P, et al. Diagnostic accuracy of [^{99m}Tc]Tc-Sestamibi in the assessment of thyroid nodules[J]. *Oncotarget*, 2017, 8(55): 94681-94691.
- [19] GIOVANELLA L, CAMPENNI A, TREGLIA G, et al. Molecular imaging with ^{99m}Tc -MIBI and molecular testing for mutations in differentiating benign from malignant follicular neoplasm: a prospective comparison[J]. *Eur J Nucl Med Mol Imaging*, 2016, 43(9): 1018-1026.
- [20] ROSARIO P W, ROCHA T G, CALSOLARI M R, et al. Fluorine-18-fluorodeoxyglucose positron emission tomography in thyroid nodules with indeterminate cytology: a prospective study[J]. *Nucl Med Commun*, 2019, 40(2): 185-187.

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